DOCUMENT RESUME

ED 343 795 SE 052 638

AUTHOR Fraser, Barry J.; And Others

TITLE Key Centre for Teaching and Research in School Science and Mathematics (Especially for Women) Report of the Activities.

INSTITUTION Curtin Univ. of Technology, Perth (Australia). Science and Mathematics Education Centre.

PUB DATE Sep 91

NOTE 85p.

AVAILABLE FROM Curtin University of Technology, GPO Box U 1987, Perth 6001, Western Australia, Australia.

PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC04 Plus Postage.

DESCRIPTORS *Educational Research; Evaluation; Foreign Countries; *Graduate Study; Higher Education; Mathematics Education; *Organizations (Groups); Postdoctoral Education; Program Descriptions; Publications; Science Education; Secondary Education

IDENTIFIERS Australia

ABSTRACT

This report describes the comprehensive activities and accomplishments of the Key Centre for Teaching and Research in School Science and Mathematics (Especially for Women) in Perth, Western Australia, in the 3-year period since it commenced in mid-1988. The following chapters are included: (1) "Structural and Organizational Arrangements"; (2) "Postgraduate Programs in Science and Mathematics Education"; (3) "Research"; (4) "Publication Program"; (5) "Face-to-Face Contact with Teachers"; (6) "Seminar Series"; (7) "Overseas Consultants and Visitors"; (8) "Evaluation of the Activities of the Key Centre by a Taskforce and a Review Panel"; (9) "Income, Especially Research Grants"; (10) "Publications and Presentations"; (11) "Cooperation with Other Institutions and Organisations"; and (12) "Future Plans." The name, thesis title, and current position of PhD students, a list of Master's theses and projects completed and currently in progress, a description of the Seminar Series sponsored by the Science and Mathematics Education Center (SMEC) and the Key Centre, the contents of eight books published by the Center, a list of publications authored by Key Centre Staff, and a list of papers presented by Key Centre Staff are appended. (KR)

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Report of the Activities of

Key Centre for Teaching and Research in School Science and Mathematics

(Especially for Women)

1988 - 1991

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September 1991

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Report of the Activities of

Key Centre for Teaching and Research in School Science and Mathematics

(Especially for Women)

1988 - 1991

Prepared by

Barry J. Fraser, Director

Lesley H. Parker, Assistant Director

L. Diane Miller, Senior Research Fellow

September 1991

36409-9-91

DIRECTOR'S FOREWORD

This report describes the comprehensive activities and accomplishments of the Key Centre for Teaching and Research in School Science and Mathematics (Especially for Women) in the three-year period since it commenced in mid-1988.

Key Centre staff during 1991 consist of a large and talented team of 13 science and mathematics educators (one Professor, five Associate Professors, three Senior Lecturers and four Lecturers, or equivalent levels of appointment) who are associated with either Curtin University's Science and Mathematics Education Centre, within the Faculty of Science, or Faculty of Education. New appointees to the Centre have been attracted from the USA, the UK, Singapore and Nigeria.

Since the inception of the Key Centre during 1988, staff have been exceptionally productive in being awarded approximately $800 000 in external and internal research grants, in authoring 240 publications and in presenting 261 conference papers.

The postgraduate programs for science and mathematics teachers offered by Curtin's Science and Mathematics Education Centre provide one of the Key Centre's major foci. These programs, with 175 postgraduate students in 1991, have approximately equal internal and external enrolments, as well as a group of fee-paying postgraduate students from Indonesia and elsewhere. Marked increases in the number of Australian teachers from interstate undertaking postgraduate studies at Curtin attest to the success of the Key Centre in its goal of being a national provider of postgraduate study opportunities for science and mathematics teachers. With 95 Master's and PhD theses and projects currently being undertaken in 1991 or completed during 1989 or 1990, Curtin postgraduate students are contributing in a major way to the Australian research effort in science and mathematics education.

The Key Centre has enhanced the quality of these postgraduate programs by developing a new gender issues unit and some new science/mathematics content units tailored to the needs and backgrounds of teachers. As well, the programs have been made more accessible to teachers through distance education provisions and opportunities for studying during school holidays. A student exchange scheme with Florida State University has provided further unique professional development opportunities for four Curtin Master's students to study in Florida and for a doctoral student from Florida to study at Curtin.

A major enhancement to the Key Centre's postgraduate offerings will take place in 1992 when a professional Doctor of Science Education degree by coursework and thesis will be introduced.

Professor Barry Fraser, Director, Key Centre

Associate Professor Lesley Parker, Assistant Director, Key Centre

A major vehicle for the massive dissemination of ideas to the vast audience of science and mathematics teachers in the approximately 2 500 secondary schools throughout Australia has been the distribution of published materials. To date, the Key Centre has distributed nationally five issues of its *News-sheet* and seven issues of its *What Research Says to the Science and Mathematics Teacher* series, as well as various advertising brochures describing postgraduate programs, publications available, and workshops and other professional development opportunities offered. Work on editing books and making videotapes currently is progressing well.

One way in which face-to-face contact with teachers is achieved is through Key Centre staff attending national and state conferences of science and mathematics teachers. Staff made 71 presentations and exhibited a Key Centre display in the exhibitors' area at 14 teachers' conferences during 1989-91. In addition, the Key Centre contributed further to teachers' conferences by making some of its eminent overseas visitors available to present keynote addresses and to run workshops in conjunction with Key Centre staff.

A major innovation on the Australian scene is the Key Centre's introduction of professional development 'institutes' which provide some teachers with an opportunity for comprehensive and in-depth study at Curtin during school holidays. An important feature of these institutes is that they can be taken for credit towards Curtin's postgraduate programs in science/mathematics education through completion of assignments in a distance education mode after the institutes have concluded. Seven institutes, most led by eminent overseas visitors, were offered during 1990-91.

Key Centre staff have pursued numerous areas of research in science and mathematics education during 1990. These included gender issues, upper school enrolment trends in science and mathematics subjects, classroom environment, Aboriginal students, factors linked with achievement, learning and teaching, and constructivist learning/teaching styles.

The Key Centre's work has benefitted from interaction with and advice from numerous eminent overseas visitors. Professor Jane Butler Kahle (USA), Professor Walter Smith (USA) and Dr Jan Harding (UK) acted as consultants on the Key Centre's gender issues work. Other overseas visitors have included Professor Theo Wubbels (The Netherlands), Professor Reinders Duit (Germany), Drs Joseph Menis and Avi Hofstein (Israel), Professors James Gallagher, Denis Phillips, Rodney Doran and Kenneth Tobin (each from the USA), Professors Alan Griffiths and Howard Birnie (Canada) and Professor Hugh Burkhardt (England).

Barry J. Fraser
Key Centre Director

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1. STRUCTURAL AND ORGANIZATIONAL ARRANGEMENTS

The Key Centre is located physically in the Applied Science building at Curtin University of Technology in the same space as that occupied by the Science and Mathematics Education Centre (SMEC), which is a funding element of the Division of Engineering and Science. However, staff from Curtin's Faculty of Education and Faculty of Science also are closely involved in the activities of the Key Centre. SMEC's increasing involvement with overseas fee-paying students, coupled with expansion associated with the Key Centre, made it necessary to appoint new staff, make suitable arrangements for the Directorship of the Key Centre, and organize additional office space.

1.1 Directorship of the Key Centre

At the time of announcement of the Key Centre during 1988, 60% of Professor Barry Fraser's time was devoted to being Head of the School of Curriculum Studies within the Faculty of Education and 40% to the role of Director of the Science and Mathematics Education Centre (SMEC). In order to provide adequate leadership to the Key Centre, he stepped aside from the role of Head of the School of Curriculum Studies and reduced his involvement in the Faculty of Education to 30% (with this time being devoted to postgraduate teaching and the supervision of postgraduate students' theses). This left 70% of his time for the Directorship of SMEC and the Key Centre. Although nominally 40% of this time is devoted to SMEC and 30% to the Key Centre, the work of the two Centres is highly integrated. These arrangements have continued to the present time.

1.2 Staff Appointments

In order to assist with the expanded activities of SMEC and the Key Centre, the following academic staff were recruited to limited-term appointments:

- **Ms Jayne Johnston** held a two-year Lecturer-level secondment from her Ministry of Education position as head of a senior high school mathematics department during 1989 and 1990.

  Professor Olu Jegede, Dean of Education at the University of Abuja, Nigeria, spent approximately a year and a half at Curtin University as a Visiting Teaching Fellow commencing in November 1988.

- **Ms Mairead Dunne**, from the University of the South Pacific, held a one-year Visiting Teaching Fellowship in 1989/1990.

- **Dr L. Diane Miller**, Assistant Professor at Louisiana State University, USA, commenced a three-year appointment as Senior Research Fellow in January 1990.

- **Dr Khoon Yoong Wong**, formerly Acting Head of Mathematics Education at the Institute of Education in Singapore, held a Lecturer position from April 1990 to July 1991.

- **Dr Tom Kandl**, Assistant Professor at Slippery Rock University in Pennsylvania, USA, was Visiting Teaching Fellow for the period April-December 1990.

- **Associate Professor Lesley Parker**, formerly Deputy Director and Acting Director of the Secondary Education Authority in Western Australia, commenced a three-year appointment in January 1991.

- **Dr Peter Okebukola**, Associate Professor at Lagos State University, Nigeria, is a Visiting Fellow for all of 1991.

- **Ms Deidra Young** commenced a three-year Postdoctoral Research Fellowship sponsored by the Australian Research Council in July 1991.

The work of full-time staff was assisted by several part-time staff (see Section 1.6). Also a number of other overseas and interstate academics have visited for periods of up to six months and contributed much by providing advice on future directions and assisting with the Key Centre's postgraduate teaching, research, publication and teacher professional development activities. Section 7 of this report provides further information about visitors.

1.3 Desktop Publishing

In order to facilitate the timely and economical publication of high-quality materials for distribution to schools, the Key Centre has purchased several Macintosh personal computers, together with a laser printer. Appropriate networking has been organised to link the different pieces of equipment. The Supplement to this report provides numerous examples of the high-quality publications which have been produced via this system of 'desktop publishing'.

1.4 Arranging Additional Office Accommodation

The expansion of SMEC (especially through its extensive overseas students programs) and the advent of the Key Centre created a need for a significant increase in office accommodation at a time when space was at a premium at Curtin. This space was needed for new academic, research assistant and support staff, as well as for the desktop publishing operation and the storage of published materials.

The Division of Engineering and Science helped to alleviate this difficult space problem by allocating five additional staff offices to SMEC and the Key Centre. One of these is located in the Applied Science building (where SMEC and the Key Centre also are housed), three are in the adjacent Physics building and one is in the Engineering building.

During 1989, Curtin University purchased a new demountable building for SMEC and the Key Centre. This new building has been useful for the Key Centre for office space for visitors, for storage of publications, and as a venue for workshops or meetings of teachers.

The Head of the School of Environmental Biology and Professor Fraser have prepared a capital works submission to the University for an extension of the Applied Science building. This extension, if approved, would provide improved accommodation for SMEC and the Key Centre, as well as for the School of Environmental Biology.

1.5 Main Full-Time Staff Associated with the Key Centre

Provided below are details of the main full-time staff who have been associated with the work of the Key Centre since its inception in mid-1988. Although some staff have appointments only with the Key Centre, most of these staff hold an appointment either in the Science and Mathematics Education Centre (SMEC) or the Faculty of Education at Curtin, as well as having a role in the Key Centre. Part-time staff are described in Section 1.6, whereas visitors to the Key Centre are listed separately in Section 7 of this report.

Dr Barry Fraser is Professor of Education and Director of the Science and Mathematics Education Centre, as well as Director of the Key Centre. His Bachelor of Science is from the University of Melbourne and his Bachelor of Education and Doctor of Philosophy degrees are from Monash University in Melbourne. Prior to coming to Curtin, he was a science and mathematics teacher with the Victorian Education Department, a Senior Tutor in Education at Monash University and a Lecturer/Senior Lecturer in Education at Macquarie University in Sydney.

Currently, Barry is Coeditor of the *International Journal of Educational Research* (Pergamon Press) and the *South Pacific Journal of Teacher Education* (Carfax Publishers) and an Editorial Board Member for *Studies in Educational Evaluation* (Pergamon Press), *New Directions in Program Evaluation* (Jossey Bass), *Research in Science and Technological Education* (Carfax Publishers), *Journal of Research in Childhood Education* (Association for Childhood Education International) and *Curriculum Perspectives* (Australian Curriculum Studies Association). His recent books include *Classroom Environment* (Croom Helm, 1986), *Windows into Science Classrooms* (Falmer Press, 1990) and *Educational Environments: Evaluation, Antecedents and Consequences* (Pergamon Press, 1991). Also Barry currently is preparing books on gender issues in science and mathematics education and on teaching and learning of science and mathematics, and he has been commissioned by the International Academy of Education to prepare a book on improving science education and by Falmer Press to prepare a handbook on science education.

Barry has received in excess of $0.5 million in research grants over the years, including two ARC (Australian Research Council) grants in 1989-91. He is the author or coauthor of over 300 publications and conference presentations. Barry currently is a Board Member of the National Association for Research in Science Teaching in the USA, and Executive Director of the International Academy of Education. Classroom environment and curriculum evaluation are two of his main ongoing research interests.

Barry's research has been recognised by eight awards in the USA. Since the inception of the Key Centre, Barry has won the Outstanding Science Educator of the Year Award (1991) and the Practical Implications Award (1988) from the Association for the Education of Teachers of Science, two Outstanding Papers Awards from the Special Interest Group on the Study of Learning Environments sponsored by the American Educational Research Association (1989 and 1991), and an Outstanding Paper Award and a Practical Implications Award from the National Association for Research in Science Teaching (1988).

Dr John Malone, Associate Professor and Assistant Director of SMEC, graduated with a Bachelor of Arts in mathematics, a Master of Education and a Doctor of Philosophy in mathematics education (conferred in 1981) from the University of Western Australia. John was Senior Master of Mathematics in the Western Australian government high school system before joining Curtin, where he has taught undergraduate mathematics and postgraduate mathematics education courses. He commenced teaching at SMEC in 1980.

Curriculum development and evaluation in mathematics are among John's principal interests, along with problem-solving, ethnomathematics and the improvement of teacher effectiveness in mathematics. He has been involved in the International Congress on Mathematical Education since 1980 and was Chief Organiser of the Curriculum Development Theme at the Budapest Congress held in 1988. He is the author or coauthor of over 40 journal articles, monographs, etc. and has been the recipient of over $170 000 in external research grants. One externally funded project resulted in the design and implementation of a bridging program for Aborigines wishing to enter higher education. He is a co-recipient of an Australian Research Grants (ARC) Small Grant in 1991 for research into the meaning of understanding in secondary school mathematics.

Associate Professor David Treagust hails from England where he obtained his initial science teaching qualifications. He emigrated to Australia in 1966 to take up a secondary science teaching position in Tasmania. He moved to Perth in 1968 and taught chemistry, science and mathematics at Scotch College for six years. During this time, he completed a Bachelor of Science degree in psychology and mathematics at the University of Western Australia. He moved to the USA in 1974 to complete Master's and Doctoral degrees with majors in science education and minors in educational evaluation and environmental science at the University of Iowa. David took a position as Lecturer at SMEC in mid-1980. In 1985, he was promoted to Senior Lecturer and, at the end of 1990, he was promoted to his current position as Associate Professor.

David's major research interests are related to the content of science teaching and include teachers' implementation of the intended science curriculum, students' learning of science concepts and content, technology education, energy and environmental education, and curriculum development and evaluation. He is the author or coauthor of approximately 90 journal articles and other publications. He served as the editor of the *Australian Science Teachers' Journal* during 1988-90 and currently is an editorial board member of the *Journal of Research in Science Teaching* during 1990. David is the recipient of over $300 000 in external research grants. International recognition of David's accomplishments include receiving the Outstanding Paper Award from the National Association for Research in Science Teaching in the USA (1985) and receiving a German Academic Exchange Service Scholarship (1986). During 1990, he received a Vice-Chancellor's EXCEL Award for excellence at Curtin University and he won a three-year research grant valued at approximately $100 000 from the Australian Research Council for work on teachers' use of analogies in science and mathematics teaching during the period 1991-93.

Associate Professor Lesley Parker was appointed in January 1991 as Assistant Director of the Key Centre. She holds a Bachelor of Science and a Bachelor of Education (First Class Honours) from the University of Western Australia. During the early part of her career, she worked as a Research Officer in Microbiology in research teams based at the University of Southern California, University College London and the Queen Elizabeth II Medical Centre at the University of Western Australia. Subsequently, her Western Australian educational career, which spans two decades, has included being a school science and mathematics teacher, a teacher educator and educational researcher, and an educational administrator. She spent the past six years in senior positions at the Secondary Education Authority, most recently as Deputy Director and Acting Director.

Lesley's educational research has addressed a wide range of curriculum issues. She is the author or coauthor of over 30 journal articles, reports and other publications. Her research focuses on the theoretical and practical ramifications of structural curriculum change, and on policy and practice in the area of gender equity. She has served on several major committees of enquiry into education at both State and national levels.

Associate Professor Geoffrey Giddings received his Bachelor of Science in chemistry from Melbourne University. Further studies at Monash University resulted in a Bachelor of Education and Master of Education with a major in curriculum. A Doctor of Philosophy in science education was conferred in 1981 at the University of Iowa. Geoff has extensive teaching experience at the secondary and tertiary levels. In 1986, he was appointed Senior Lecturer in the Faculty of Education at Curtin University, where currently he is Associate Professor and Head of the School of Curriculum Studies.

The design, management and teaching of both school and teacher education programs in science and mathematics are strong components in Geoff's background. He has been a visiting specialist at the Chelsea College Science Education Centre at the University of London and a visiting professor in the Science Education Center at the University of Iowa (USA). Additionally he served as head of the project team working on a TAFE-funded tutor evaluation project for the Council of Adult Education (CAE) in Victoria (1983-84). Geoff is the author or coauthor of over 50 journal articles, consultancy reports and other publications. He is the recipient of over $100 000 in research grants. Currently, he is on the editorial board for *Research in Science Education* and, up until the end of 1990, was editor of the research section of the *Australian Science Teachers' Journal*.

Dr Léonie Rennie, a Western Australian, has Bachelor degrees in Science (Geology) and Education, a Master's degree in Education and a Doctor of Philosophy in science education, all conferred by the University of Western Australia. In addition to being a secondary science teacher of physics, chemistry and biology, Léonie has undertaken curriculum development and advisory work in rural schools in her role as Education Officer. Léonie taught at the University of Western Australia since 1973 until she was appointed as Senior Lecturer at SMEC in 1988.

Léonie's major research interests include gender issues in science and mathematics education and affective aspects of science and technology education. She is the author or coauthor of over 35 articles in state, national and international journals and other publications. Among the awards received in recognition of her accomplishments are the Bertha Houghton Prize in Education, the Convocation Prize in Education, a Commonwealth Postgraduate Research Award, and the R G Cameron Prize in

Education. For 1991, she has an ARC (Australian Research Council) Small Grant for a study involving a hands-on science centre.

Dr L. Diane Miller was appointed as a three-year Senior Research Fellow in the Key Centre and SMEC in January 1990. Coming from the United States, she graduated with a Bachelor of Science in mathematics and physical science education from the University of Tennessee-Knoxville. A Master of Science in mathematics was completed at Memphis State University, with a Doctor of Philosophy in mathematics education conferred at the University of Missouri-Columbia in 1986. In addition to teaching secondary mathematics, physics and chemistry, Diane has taught undergraduate mathematics and graduate mathematics education courses. She has conducted numerous workshops for teachers of mathematics at the elementary and secondary levels in the US and completed a three-week consultancy in Thailand (1989) involving professional development for mathematics teachers.

Diane's research activities have included studies examining students' attitudes towards mathematics and the anxieties experienced during the learning process. More recently, her interests have engaged her in projects relevant to the design of teacher inservice programs in mathematics education and teacher effectiveness in teaching mathematics. She has authored or coauthored over 20 scholarly publications and has served as associate editor of ***AMP-Line***, published jointly by the Mathematics Association of America and the National Council of Teachers of Mathematics. Diane is the co-recipient of approximately $1 million from the National Science Foundation and the State of Louisiana for developing and testing new models for training mathematics teachers. She is the co-recipient of a 1991 Small Grant from the Australian Research Council for research on the meaning of understanding in the context of secondary mathematics.

Dr Helen Mansfield holds a Bachelor of Arts and a Master of Education from Adelaide University. Her Doctorate in Education was conferred in 1984 at the University of Georgia (USA). Her experiences include teaching secondary mathematics, tutoring in education at Flinders University and serving as a lecturer in mathematics education at the Western Australian College of Advanced Education. Having a thorough knowledge of current theories and practices in mathematics education throughout the world, Helen has acted as a consultant for courses at the Regional Centre for Education in Science and Mathematics in Penang, Malaysia and has been involved with the Philippines-Australia Science and Mathematics Education Project during 1989-90. She was appointed as a Senior Lecturer in the School of Curriculum Studies in the Faculty of Education at Curtin University of Technology in 1987.

Helen's primary research interest is the teaching and learning of concepts in geometry. She recently was awarded approximately $38 000 from the Australian Research Council for a project 'Identifying Students' Misconceptions in Geometry and Developing Teaching Strategies to Promote Conceptual Change'. Helen is the author or coauthor of over 20 articles, chapters or monographs and is currently Coeditor of *Cross Section*, a journal of the Mathematical Association of Western Australia.

Dr Diane Miller (right, Senior Research Fellow) with Jayne Johnston (previously Lecturer and now part-time staff member)

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Mr Peter Taylor graduated from La Trobe University with a Bachelor of Science degree, majoring in physics, and a Diploma in Education. He completed a Master of Education at the University of Bath (England) in 1981. He has taught high school physics, science and mathematics and worked in various educational institutions including comprehensive schools and technical colleges. He is currently undertaking a Doctor of Philosophy at Curtin University. In 1985, he was appointed as a Research Fellow at SMEC to work on the development of bridging programs for Aborigines wishing to gain access to undergraduate science and mathematics courses. He now holds a tenured position as Lecturer. Among his contributions to education at the international level, Peter served a three-week consultancy in science and mathematics education in Indonesia in January 1989.

Peter Taylor (right, Course Coordinator) with postgraduate students

Peter currently is involved in teacher effectiveness research with a focus on the transmission and acquisition of mathematical content knowledge. He is the author or coauthor of over 20 publications including two school mathematics texts, *Mathematics for Secondary School*, published by Longman in the UK. He is the co-recipient of approximately $100 000 in research grants and the recipient of the 1989 Early Career Award from the Western Australian Institute for Educational Research.

Dr Khoon Yoong Wong is a native of Malaysia. He received a Bachelor of Science with first class honours and Diploma in Education from the University of Tasmania. His Doctor of Philosophy was conferred at the University of Queensland in 1985. His experiences include teaching secondary mathematics and working in the professional development of mathematics teachers in Malaysia. His previous appointment was acting Head of the Mathematics Education Department at Singapore's Institute of Education. He was the leader of a Singapore team which completed a Computers in Education project sponsored by RECSAM. Dr Wong commenced a limited-term appointment as Lecturer and Course Coordinator at Curtin in April 1990 and finished in July 1991.

Khoon Yoong Wong's research interests are mathematical learning and teaching, metacognition and study skills, and computer-based instruction. He has authored seven mathematics textbooks in Malay and coauthored 30 mathematics texts for Hong Kong secondary schools. His journal articles and conference presentations number about 20. Recently he developed a logo microworld on geometric transformations and matrices which is being made available free of charge to mathematics teachers during 1991.

Mr Richard Lowe joined the Faculty of Education at Curtin University in 1990 as a Lecturer in instructional design and educational technology, but he also has an extensive background in science education. After completing a Bachelor's degree in chemistry, he taught a variety of high school science subjects for a total of 12 years and spent several years as a production and development chemist in the paint industry. In 1980, he was appointed to the Curriculum Branch of the Education Department of Western Australia to write materials for the Physical Science course. Before coming to Curtin, Richard spent six years at Murdoch University in training student teachers for both primary and secondary schools, particularly in the area of science education. During this time, he completed a Master of Education degree at Curtin and is currently nearing the completion of a Doctoral degree at Murdoch.

His major research interest is in the cognitive processing of instructional diagrams, particularly as this applies to the design and interpretation of diagrams used in learning science. He is the author or coauthor of approximately 30 journal articles and other publications.

Ms Jayne Johnston completed a Bachelor of Science in mathematics, a Bachelor of Education and a Master of Science Education at the University of Western Australia. She has extensive teaching experience at the secondary level and was approved to the position of Senior Teacher of Mathematics in a Western Australian high school in 1988. She was seconded from the Ministry of Education in January 1989 to take up a two-year position at SMEC and the Key Centre. Jayne had lecturing and administrative responsibilities in the Philippines-Australia Science and Mathematics Education Project in 1989-90.

Jayne's research interests include gender issues in mathematics, curriculum development and the professional development of teachers. She acted as a consultant to the National Advisory Group for the Commonwealth Girls in Mathematics and Science

Project (1988-90), the National Working Party on the Gender Inclusive Calculus Project (1988-90), the Western Australian Ministry of Education for the Monitoring Standards in Education Project (1989) and the implementation of the Upper Secondary Mathematics Syllabus (1989-90). Jayne has been awarded the 1991/1992 Commonwealth Relations Trust Fellowship, offered through the Nuffield Foundation in Britain and the Western Australian Ministry of Education. She will commence her doctoral studies at the Institute of Education at the University of London in October 1991.

Professor Olu Jegede, Dean of Education at the University of Abuja, Nigeria, spent approximately a year and a half at Curtin University as a Visiting Teaching Fellow commencing in November 1988. He holds the degrees of Bachelor and Master of Science Education (biology) from Ahmadu Bello University, Zaria, Nigeria and a Doctor of Philosophy in science education in 1981 from the University College, Cardiff, Wales, United Kingdom. He has taught biology and integrated science at the secondary school level, biology at the College of Education, Owerri, Nigeria and several undergraduate and postgraduate science education courses at universities.

The research areas of interest to Olu include instructional and learning strategies in science, psychosocial environment and learning within science classrooms (with particular reference to socio-cultural influences, science, technology and society issues) and curriculum development and evaluation in biology and integrated science. He was the Vice-President of the Science Teachers' Association of Nigeria (1983-86) and currently serves on the Editorial Board of the *Journal of the Science Teachers' Association of Nigeria*. He is the author or coauthor of over 100 journal articles and other publications which include six biology and integrated science books currently in use in Africa and the Caribbean.

Associate Professor Peter Okebukola, of Lagos State University in Nigeria, is spending a whole year as a Visiting Fellow at Curtin University from November 1990 to November 1991. He holds an Honours degree in botany and Master's and PhD degrees in science education from the University of Ibadan. He has taught science in Nigerian secondary schools for numerous years, before taking up positions in higher education at Oyo State College of Education and Lagos State University.

His research interests lie in the social psychology of science learning, with particular emphasis on cooperative methods, program evaluation, cognitive preferences and meta-analysis of research. He is author of several school science textbooks and a large number of journal articles and conference papers. Currently he is on the Editorial Board of the *Journal of Research in Science Teaching* and a Consulting Editor for *The Science Teacher* in the USA, as well as being Managing Editor of *Educational Perspectives* and Associate Editor of the *Teaching of Research in Curriculum* in Nigeria.

Dr Tom Kandl was a Visiting Teaching Fellow at Curtin for most of 1990. He comes from Slippery Rock University in Pennsylvania in the United States. Tom completed a Bachelor of Science majoring in psychology and mathematics at the State University of New York College at Brockport. His Master of Arts major in curriculum and instruction emphasised mathematics education and computer applications in education. His Doctor of Philosophy in curriculum and instruction continued this same focus. Both degrees were conferred at Michigan State University. In addition to teaching mathematics in Grades 7-12, Tom has been an instructor of educational psychology and mathematics education courses at the tertiary level.

Tom's research interests in mathematics education continue to focus on computer applications in education. He received a $30 000 Pennsylvania State Grant (1987-88) to work with public school teachers to integrate mathematics, science and computers/software better into their teaching. Tom has presented at state and national conferences including the Annual Ethnography in Education Research Forum held at the University of Pennsylvania.

Ms Mairead Dunne, whose home is in Dublin, received her formal education in England by completing a Certificate in Education at the University of Southampton and a Master of Arts in Education at Sussex University. She has extensive experience in teaching and curriculum development in the 'developing' countries of Kenya and Fiji. She was a lecturer in education and a consultant in science education at the University of the South Pacific, Suva, Fiji. Mairead began a one-year appointment as a Visiting Teaching Fellow at Curtin University in August 1989. Her research interests include gender issues in education, socio-cultural factors influencing learning in science, and education and national development. She is the author or coauthor of over 10 journal articles, monographs and books.

Dr Deidra Young was born in Canada and holds a science degree from the University of Western Australia, a Diploma of Education from Murdoch University and a Postgraduate Diploma and Master's degree in science education from Curtin University. During 1991, Deidra became the first person to fulfill the requirements for a Doctor of Philosophy in science education from Curtin. Deidra's interests include gender issues in science education and methodological issues associated with the secondary analysis of large data bases. She has held various teaching and research assistant positions before becoming a Senior Research Officer for the Women's Cancer Prevention Unit of the Health Department of Western Australia.

Dr Deidra Young (right, Postdoctoral Research Fellow) with Professor Barry Fraser

Currently Deidra is the recipient of a Postdoctoral Research Fellowship from the Australian Research Council valued at approximately $130 000 over three years. She is working under Professor Barry Fraser's supervision on a project entitled 'Socio-Educational and Environmental Factors Influencing Mathematics and Science Achievement in Australian Schools'.

1.6 Part-Time Staff

The Key Centre's full-time staff listed above receive invaluable assistance from a small team of part-time staff. The main four part-time staff of SMEC and the Key Centre are described below.

Dr John Wallace holds a Bachelor of Applied Science, Bachelor of Education and Master of Applied Science (Science Education) from Curtin University of Technology, as well as a PhD from the University of Toronto. John has worked for approximately 20 years with the Ministry of Education of Western Australia, initially teaching science in schools for 15 years and later working in curriculum development and school development. Currently he is in the policy area within the Ministry. His research interests include teachers' knowledge, formation of teachers' images and primary science. In addition to teaching external students, John has acted as a consultant to the Key Centre and has contributed to the planning of several of the Key Centre's dissemination and professional development initiatives.

Dr Peter Lewis completed a first class honours degree and a PhD in chemistry at Monash University before undertaking a Diploma in Education (Monash University), a Graduate Diploma in Educational Administration (Deakin University) and a Master of Applied Science (Science Education) (Curtin University). He has extensive experience as a science teacher both in Victoria and Western Australia. Peter has held the positions of Head of Chemistry and Head of Science at Christ Church Grammar School in Perth, before taking up his current post of Dean of Studies at that school. He has written three school chemistry textbooks and has undertaken research into the pedagogical content knowledge of experienced science teachers. Currently he is involved in teaching and writing teaching materials for the Key Centre's external postgraduate programs.

Ms Jayne Johnston who was on the full-time staff during 1989-1990 (see Section 1.5), joined the Key Centre as a part-time staff member in 1991.

Ms Gail Manton holds a Bachelor of Applied Science in biology, a Graduate Diploma in Education, a Postgraduate Diploma in Science

Part-time staff, Dr John Wallace (left) and John Hogan (middle), with Associate Professor John Malone

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Education (with Distinction) and a Master of Applied Science (Science Education), all from Curtin University. She has worked as a scientist in research and medical organisations and has a long teaching career with the Ministry of Education of Western Australia in secondary schools and at Tuart Senior College. She has been involved over several years in external teaching of Key Centre courses.

Mr John Hogan, currently Head of Mathematics at Kalamunda Senior High School in the Perth metropolitan area, has had many years of experience as a teacher and consultant with the Ministry of Education of Western Australia. He holds degrees in both mathematics (Curtin University) and education (Murdoch University) and currently is pursuing a Master of Philosophy at Murdoch University. John has been involved in planning and running the short courses for science and mathematics teachers in the Western Australian area described in Section 2.9.

2. POSTGRADUATE PROGRAMS IN SCIENCE AND MATHEMATICS EDUCATION

2.1 Background Information

Curtin University is unique in terms of the programs which it offers to qualified secondary school science and mathematics teachers. The programs are the Postgraduate Diploma in Science/Mathematics Education, the Master of Science (Science/ Mathematics Education), which is available for study either by thesis only or by coursework plus project, and the doctoral degree. All programs are readily accessible to students throughout Australia through distance education provisions. As these already-existing programs offer outstanding professional development opportunities for science and mathematics teachers, the Key Centre is publicising them more widely, making individual units more accessible and enhancing the programs in the various ways described later in this report.

Although previously doctoral study has been available only as a PhD by thesis, another doctoral program which consists of a combination of advanced coursework plus a thesis will become available in 1992 (see Section 2.11).

In addition to units in science and mathematics education, these postgraduate programs are noteworthy in that the Postgraduate Diploma and the Master's by coursework involve the compulsory study of some content units in science and mathematics taught by staff of the Faculty of Science. Various options in education also are available. The course brochure provided as Attachment 1 in the Supplement to this report gives further information about these postgraduate programs and individual units within them.

2.2 Enrolment Numbers

Curtin University continues to have the largest group of postgraduate students specifically in science and mathematics education of any higher education institution in Australia. Table 1 shows the approximate number of students enrolled in Curtin University's postgraduate programs in science and mathematics education during 1989-1991. These figures are broken down separately for Australian students based in Perth, Australian students from interstate and country areas of WA, and fee-paying overseas students, and are shown for the three separate programs — Postgraduate Diploma, Master of Science and PhD.

Table 1 shows that, with over half of its Australian students residing outside Perth, the Key Centre is meeting its goal of being a national (not just a local) provider of postgraduate study opportunities for science and mathematics teachers.

Table 1 also highlights the dramatic overall increase in Australian student enrolments (approximately 64%) occurring between 1989 and 1991, thus attesting to the Key Centre's success in expanding its national reputation through the modes of publicity outlined in Section 2.3 below.

The availability of units in the Postgraduate Diploma and Master's by Coursework in the distance education mode has made these coursework programs readily accessible to teachers from anywhere in Australia, whether they are teaching in capital cities or in country areas. For example, as Table 1 shows, the number of Australian students outside Perth undertaking the Postgraduate Diploma has risen remarkably from 26 in 1989 to 39 in 1990 and to 56 in 1991 (i.e., an overall increase of 115% between 1989 and 1991). For students residing outside Perth, there also exists the opportunity to undertake thesis degrees at either the Master's or PhD level by communicating with Curtin supervisors by mail, telephone, facsimile and electronic mail, and in person during conferences attended by students and Key Centre staff and through visits to Perth typically during school holiday time.

Table 1 also provides some information about the number of overseas fee-paying students undertaking postgraduate studies in science and mathematics education during 1989-91. The majority of these overseas students were part of one of two major projects. The first group was from Indonesia and comprised 20 fellows in 1989 (12 Master's and eight Postgraduate Diploma) and 16 fellows in 1991 (seven Master's and nine Postgraduate Diploma). These students were associated with a project, funded by the Indonesian government and managed by the IDP (International Development Program), which aimed to train selected science and mathematics teachers in Indonesia to lead curriculum reform and teacher professional development upon return to their own

Associate Professor David Treagust (top right) with Indonesian students

regions. The other large group, consisting of 31 Filipino mathematics teachers in 1989 and another 34 in 1990, was part of a project funded by AIDAB (Australian International Development Assistance Bureau) and conducted jointly with Edith Cowan University. Although the Filipino fellows undertook a postgraduate program based on the Postgraduate Diploma in Science/Mathematics Education, they followed a 'non-award' program which led to their gaining a special certificate rather than the formal Postgraduate Diploma. As with the Indonesian fellows, the Filipino fellows underwent training which prepared them to educate other mathematics teachers back in the Philippines to teach the new mathematics curriculum.

2.3 Publicity of Postgraduate Programs

The Key Centre has been involved in publicising Curtin's postgraduate programs in science and mathematics education in the following ways:

- Postgraduate programs have been advertised nationally in newspapers and science and mathematics teachers' journals on several occasions. *The Australian* and *The West Australian* newspapers were used as well as the *Australian Science Teachers' Journal* and the *Australian Mathematics Teacher*. In addition, newsletters of the Ministries/Departments of Education in some States/Territories provided advertising free of charge.
- An attractive brochure describing postgraduate programs was redesigned and reprinted during 1990 and again in August 1991. This brochure was distributed to people replying to newspaper or other forms of advertising, as well as being made available to the Head of Science and Head of Mathematics in every secondary school throughout Australia as part of a Key Centre mailing. It also was made available when Key Centre staff attended annual conferences of national and State associations of science or mathematics teachers. A copy of the most recent version of this brochure is provided as Attachment 1 in the Supplement to this report.
- Postgraduate programs also were advertised in the *News-sheets* and the *What Research Says* series, which are published by the Key Centre and distributed to all 2 500 secondary schools in Australia. More information about these publications is contained in Section 4 and samples of the publications are provided in the Supplement to this report.
- The Key Centre designed a special insert to an edition of the *Australian Science Teachers' Journal* and the *Australian Mathematics Teacher* during 1990 (see a copy of the science teachers'

TABLE 1. Approximate Number of Students Enrolled in Postgraduate Programs in Science and Mathematics Education at Curtin University during 1989-91

Program	Location of Students	Number of Students					
		1989		1990		1991	
		Aust	O/seas	Aust	O/seas	Aust	O/seas
Postgraduate Diploma in Science/Mathematics Education	Perth-based	18	39[a]	14	34[b]	14	9[c]
	Interstate or Country WA	26		39		56	
	Total	44		53		70	
Master of Science (Science/Mathematics Education)	Perth-based	8	12[d]	21	1[e]	33	9[f]
	Interstate or Country WA	36		29		30	
	Total	44		50		63	
PhD	Perth-based	6		7		14	3[g]
	Interstate or Country WA	-		3		7	
	Total	6		10		21	
Total for all Programs	Perth-based	32	51	42	35	61	21
	Interstate or Country WA	62		71		93	
	Total	94		113		154	

[a] 8 fellows in Indonesian program and 31 fellows in Filipino program.

[b] 34 fellows in Filipino program.

[c] 9 fellows in Indonesian program.

[d] 12 fellows in Indonesian program.

[e] 1 Indonesian student funded by AIDAB

[f] 7 fellows in Indonesian program, plus 1 Indonesian and 1 Tongan student sponsored by AIDAB.

[g] 1 student from Nigeria, 1 from PNG and 1 from Singapore.

insert in the Supplement as Attachment 2). Among other things, these journal inserts incorporated advertising for the postgraduate programs.

- A comprehensive display (see Section 5.2) has been designed for erection in the exhibitors' area when Key Centre staff attend national or State conferences of science or mathematics teachers. This display promotes all aspects of the Key Centre's work, including its postgraduate programs. The course brochure in the Supplement is made available on the tables in front of this display.

2.4 PhD Students

As Table 1 shows, there recently has been a marked increase in PhD enrolments from six in 1989 to 10 in 1990 and to 24 in 1991. Appendix A provides further details of the 24 PhD students enrolled in 1991, including each student's name, thesis title, current position and place of residence. Of the 24 current PhD students, 14 reside in Perth, seven reside interstate (two from Victoria, two from South Australia and one each from the Northern Territory, Queensland and Tasmania) and three are from overseas (one each from Nigeria, Singapore and PNG). Eight of the PhD students currently are employed in teaching posts in universities, six are full-time students, and the remaining 10 are employed in secondary schools or other occupations related to science and mathematics education.

Susan Stocklmayer, full-time doctoral student

The following four PhD students are supported by scholarships for full-time study at the time of writing this report:

- *Susan Stocklmayer*, after seven years of teaching physics, chemistry and lower school science, commenced a doctoral thesis on experts' and novices' images of electricity. Sue recently received the Shell Science Fellowship for 1991 and represented Australian science teachers at the 14th Singapore Youth Science Fortnight. She escorted Emma Runciman of St Paul's Anglican Grammar School, Warragul, Victoria and David O'Connor from Heathfield High School, South Australia, whose projects were displayed at the Science Fair.

- *Rodney Thiele* is currently on study leave after teaching chemistry and general science for the last four years. His doctorate involves teachers' and students' use of analogies in secondary chemistry education.

Full-time doctoral students, Rod Thiele and Dorit Maor

- *Dorit Maor* has taught secondary school biology in Israel. Her interest in utilizing an inquiry approach to learning combined with an interest in promoting the use of computers in education has led to the design of her doctoral study which investigates how students develop inquiry skills while they interact with a computerised database, *Birds of Antarctica*, which she authored.

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- *Suleiman Idiris* comes from Nigeria, where he has occupied key offices in some post-primary schools of Kaduna State. He is the co-author of a series of junior agricultural science books, including teachers' guide. His doctoral study is investigating the nature and effects of the learning environment in agricultural science classrooms in Nigeria.

In addition, *Craig Bowen* is studying at Curtin under the Curtin-FSU (Florida State University) Student Exchange Scheme (see Section 2.9). His interest in chemistry education at the tertiary level has led him to focus on the interpretations that students make of their experiences in university chemistry classes. One aspect of his dissertation has to do with the development of a learning environment inventory examining curricular practices that take place in university classrooms.

2.5 Theses and Projects Undertaken by Master's Students

Appendix B provides the title of the 71 theses or projects in science/mathematics education currently being undertaken or completed during 1989 or 1990 for the Master of Science (Science/Mathematics Education). Theses and projects are listed separately, with an indication whether they are ongoing or were completed in 1989 or 1990. This list highlights the vast amount of research in science and mathematics teaching being undertaken at Curtin, and also shows that most theses/projects have a practical orientation aimed at improving the teaching and learning of science and mathematics.

2.6 New 'Gender Issues', 'Special Topics' and Science/Mathematics Content Units

In 1990, several new units, especially suited to the needs and backgrounds of teachers, were introduced. The units are available for distance education study as well as internal study in order to cater for teachers all around Australia. These units include:

- *Gender Issues in Science and Mathematics Education* was offered to both internal and external students for the first time in 1990. Dr Léonie Rennie and Ms Jayne Johnston from the Key Centre, and Associate Professor Lesley Parker (now of the Key Centre, but still Deputy Director of the Secondary Education Authority during 1990) planned the unit and were responsible for its teaching. Input from visiting scholars, Professor Jane Butler Kahle (Miami University, Ohio, USA) and Dr Jan Harding (Equal Opportunities Consultant, UK) also contributed to the development of this unit (see Section 7.1). The unit covers: the nature and extent of the gender/science/mathematics problem; theoretical models relevant to gender, science and mathematics; analysis of the structure, curriculum and assessment in science/mathematics educational environments and the interactions which occur in these environments, together with the development of gender-inclusive approaches to science and mathematics education. Preparation of a number of resources continued through 1990, including a book of readings edited by Lesley Parker, Léonie Rennie and Barry Fraser (see Section 4.4) and two videotapes featuring interviews with Dr Dale Spender, Dr Jan Harding and others (see Section 4.5).

- *Special Topics in Science and Mathematics Education*. This unit is designed to capitalise on the wealth of expertise regularly brought to the Key Centre through a steady stream of overseas visitors. The idea is that long-term visitors offer a unit on topics which are relevant to science and mathematics teachers and which are in their special areas of expertise. This unit also provides a convenient vehicle for enrolling students for credit in the professional development institutes described in Section 5.5.

- *Contemporary Issues in Science* has been developed by staff of several schools within Curtin's Faculty of Science. The unit's rationale is consistent with the notion that knowledge about science is a continually evolving process; as new technology and new information become available, people are required to modify their views of the world and to make judgements and decisions based upon their understanding of this information. The future of the Earth and life upon it literally depend on the correctness of these decisions. People today need to be able to think about the issues involved in contemporary science and need to be aware of the risks and consequences attached to their decision-making. The unit consists of six components: two each in chemistry, physics and biology. The teaching staff for this unit includes Professor John de Laeter, Deputy Vice-Chancellor for Research and Development, Associate Professor Jeff Dunn in Applied Chemistry, Dr Monica Leggett, Physics Lecturer at Edith Cowan University, and Associate Professor Jonathan Majer in Environmental Biology.

- *Applicable Mathematics for Secondary School Teachers* was developed jointly by staff from the Key Centre and the School of Mathematics and Statistics. The unit addresses topics of modern and applicable mathematics directly usable in the secondary classroom. It makes available useful background material on a variety of mathematical subjects including numerical mathematics, mathematics of image processing, statistics and application to modelling physical systems, probability and paradoxes, simulation and stochastic processes, operations research and discrete mathematics, graph theory and combinatorics. The teaching staff for this unit includes Associate Professor Bill Perriman, Dr Lou Caccetta and Mr Brian White from the School of Mathematics and Statistics and Associate Professor John Malone from the Key Centre.

2.7 Increasing the Accessibility of Postgraduate Programs and Units

In order to increase Australia-wide access to Curtin's postgraduate programs, new or revised versions of internal study courses are being developed and offered on an external study basis. In addition to the Gender Issues, Contemporary Issues in Science and Applicable Mathematics units described above, some of the titles of units recently or currently being written or revised include Physics Education 508, Chemistry Education 504, Mathematics Education 507, Integrated Science Education 506, Science/Mathematics Education 611 (Teaching and Learning in Science and Mathematics), Science/Mathematics Education 612 (Science and Mathematics Curricula) and Science/Mathematics Education 613 (Supervising Science and Mathematics Programs).

As Section 2.8 shows, the Key Centre also has created opportunities for teachers to undertake postgraduate studies during their school holidays through its 'professional development institutes'. In addition, for the first time, the Key Centre scheduled several units from its Postgraduate Diploma program for study in the distance education mode during the 1990-91 summer school holidays. The advertisement for these external study opportunities provided as Attachment 3 in the Supplement to this report was distributed to all secondary schools in Australia through one of the Key Centre mailings. Feedback from teachers suggests that these study opportunities during school holidays have increased accessibility for teachers who feel that they are too busy to undertake postgraduate study during the normal teaching year.

Another way in which the Key Centre's postgraduate programs have been made more accessible is by offering certain units on a not-for-credit basis (in both the internal and external study modes). This caters for teachers who want to undertake a particular unit, but don't necessarily wish to enrol in an entire program. For example, the new science and mathematics content units described in Section 2.6 and the professional development institutes described below have been widely advertised for study on a not-for-credit basis.

2.8 Professional Development Institutes

Section 5.5 of this report describes some innovative professional development institutes which teachers can undertake during their school holidays. Although institutes can be taken on a not-for-credit basis, a most important feature of these institutes is that they can count for credit towards Curtin's postgraduate programs in science and mathematics education if students complete assignments in the distance education mode after the completion of the institutes. Advertising brochures for these institutes, were mailed to every secondary school in Australia (e.g., Attachments 4 and 5 in the Supplement).

2.9 Short Courses

Another innovation within Curtin University's postgraduate programs is its short courses, which typically carry only about half of the credits as normal postgraduate units. One of the reasons for introducing short courses is to make available to students the expertise of eminent overseas visitors who are at Curtin for too short a time to enable them to teach whole-semester units. For example, during second semester 1991, the following two half-semester short courses are being offered by overseas scholars:

- *Contemporary Issues in Assessment and Evaluation (Professor Irvin Lehmann, Michigan State University).* This course, in August-September 1991, focuses on various topics that are of current relevance to science and mathematics teachers, including: norm-referenced and standards-referenced assessment; planning, developing and administering tests; assessment of project and laboratory work; recording, reporting and profiling; moderation; rating scales, observations and checklists; and attitude assessment.
- *Philosophical Issues in Educational Research (Professor Denis Phillips, Stanford University).* This course, in September-November 1991, will focus on various topics that will promote a better understanding of the educational research literature and provide excellent preparation for anyone intending to undertake research as a postgraduate student. Topics will include: the value-laden nature of educational research; the controversy over the choice of qualitative or quantitative methods; whether educational research is like research in the natural sciences; whether truth and objectivity are outmoded in educational research; and the implications and misimplications of Kuhn's work on paradigms and scientific revolution.

The advertisement for the Lehmann and Phillips short courses is provided as Attachment 6 in the Supplement to this report.

During 1991, the Key Centre instigated another unique series of short courses which run for three and a half hours during school time on a fortnightly basis over one school term. Like the professional development institutes described in Section 5.5, these short courses can be attended either on an interest-only basis or can be used to gain credit towards the Key Centre's postgraduate programs (by undertaking written assignments). Each participant receives a certificate of attendance. These short courses are run by full-time and part-time staff of the Key Centre in conjunction with a current Head of Science/Mathematics department in a Perth school. The following two courses were run during 1991:

- *Heads Up for Science and Mathematics: The Role of the Head of Department in Supervising Science/Mathematics Teachers.* This course, run in Term 2, was designed to support Heads of Science and Mathematics in their roles as supervisors of teachers and leaders in teaching. It provided opportunity for sharing experiences and ideas and to develop and practice planning and other skills. Topics included leadership, developing a subject plan, supervision, school development and professional development.
- *Content and Strategies for Teaching the TEE Course: Introductory Calculus.* Term 3 involved a course which was designed to provide upper secondary mathematics teachers with the necessary background knowledge, skills and methodologies to support their class teaching in the new subject 'Introductory Calculus'. The course covered content (especially differentiation, integration and their applications), methods of teaching the content by way of investigative, modelling and collaborative approaches, ways to utilise technology and approaches to assessment. Between sessions, participants had the opportunity to try strategies and approaches to teaching in their own schools and then to discuss them at subsequent course sessions.

The advertisements for the above two short courses for teachers in the Perth area are provided as Attachments 7 and 8 in the Supplement to this report.

2.10 Curtin-FSU (Florida State University) Student Exchange Scheme

Curtin and FSU have signed an official agreement which allows the exchange of postgraduate students in science and mathematics education. A Curtin student can go to FSU for a semester or a year to undertake units which are credited towards a Curtin degree. Similarly, an FSU student can undertake units at Curtin and obtain credit for them towards an FSU degree. Fee waivers have been agreed to by both institutions. Assistance with air fares and part-time employment are provided by each institution. A Curtin Master's student (Gary Casey) studied in Florida under this scheme in 1989, and two other Curtin Master's students (Loren White and Robyn White) spent a whole year in Tallahassee in 1990. The first American PhD student under the scheme, Craig Bowen, studied at Curtin during first semester, 1991. Another Curtin Master's student, Terry McClafferty, is studying at Florida State University in the second half of 1991.

Students involved in Curtin-FSU exchange scheme – Loren White (top), Craig Bowen (left) and Terry McClafferty

2.11 Introduction of a Professional Doctorate in Science, Mathematics and Technology Education by Coursework and Thesis

A major innovation on the higher education scene is the Key Centre's instigation of Australia's first professional doctorate in science, mathematics and technology education by coursework plus thesis. Whereas the Key Centre's existing thesis-only Doctor of Philosophy (PhD) program caters well for science/mathematics teachers wishing to change their careers to become academics or educational researchers, it is not ideal for teachers wishing to improve aspects of their professional practice through enhancing their knowledge and skills. For these teachers, a more relevant doctoral program would consist of a combination of advanced-level courses which are oriented towards improving some aspect of practice, together with a practically-oriented research thesis.

The new professional doctorate, the *Doctor of Science Education (ScEdD)*, consists of 65% research thesis and 35% coursework, which involves a selection of units from the following list:

- Teaching and Learning in Science, Mathematics and Technology
- Science, Mathematics and Technology Learning Environments
- Science, Mathematics and Technology Curricula
- Inclusive Curricula in Science, Mathematics and Technology Education: Gender Issues
- Inclusive Curricula in Science, Mathematics and Technology Education: Ethnicity Issues
- Constructivism in Science, Mathematics and Technology Education
- Leadership and Professional Development for Science, Mathematics and Technology Education
- Educational Technology and Computing in Science, Mathematics and Technology Education
- Advanced Research Methodology
- Special Topics in Science, Mathematics and Technology Education.

The ScEdD and PhD are identical in terms of entry requirements, minimum and maximum enrolment periods, methods of thesis examination, etc. As with all other postgraduate programs sponsored by the Key Centre, the ScEdD will be accessible to all teachers nationally through the use of distance education methods for all coursework and most of the thesis; however, some time must be spent at Curtin University when working on the thesis component.

In order to motivate and facilitate more teachers to undertake study at the doctoral level via either the research-only Doctor of Philosophy or the coursework-plus-thesis Doctor of Science Education, the Key Centre has instigated the two types of scholarships described below.

Attachment 9 in the Supplement to this report contains the advertisement for the Key Centre's Doctor of Philosophy and Doctor of Science Education which was mailed to the Heads of Science and Mathematics in every secondary school throughout Australia.

2.12 New Key Centre Scholarships for Doctoral Study

Already several of the Key Centre's doctoral students currently hold either a Commonwealth government Australian Postgraduate Research Award (APRA) or a Curtin University Postgraduate Award for full-time doctoral study. These scholarships provide a tax-free living allowance ($12 734-$16 433 p.a. in 1992). In addition to these scholarships, the Key Centre has initiated two of its own types of scholarships to be implemented in 1992.

Key Centre 'Top Up Scholarships' provide new full-time doctoral students with an additional tax-free stipend of $4 000 p.a. which can be held simultaneously with an Australian Postgraduate Research Award or a Curtin University Postgraduate Award. The purpose of these scholarships is to make the Key Centre a financially attractive place at which to undertake doctoral studies. They are applied for at the same time as applying for APRAs or Curtin Awards.

Key Centre Travel Scholarships assist part-time doctoral students living outside Perth with some of the expenses associated with travelling to Curtin University for short periods of study. The purpose of these scholarships is to make the Key Centre's doctoral programs more accessible to teachers residing interstate or in country areas of Western Australia.

3. RESEARCH

The Key Centre already has initiated significant research projects in the various areas outlined below. New research projects will continue to be initiated in these areas in the future.

3.1 Girls in Science and Mathematics Education

Research in the area of gender issues in science and mathematics has been a major thrust. A particular focus has been the effect of the Unit Curriculum in Western Australia and the inequities in enrolment patterns which result when students are given earlier choice in their selection of subjects. Together with David Wood and Leon DeLeuil of the Science Teachers' Association of Western Australia, Léonie Rennie conducted the third review of the effects of the Unit Curriculum in Science. Gender inequities in enrolments appear to be decreasing slowly as schools begin to make their own adaptations to the implementation of the science curriculum within the Unit Curriculum structure. Changes in the attitudes of males and females towards technology and technology education have been part of two other projects involving monitoring of the implementation of technology programs in primary and secondary schools.

Analysis of data relating to gender-stereotyping in career choices is completed, and Léonie Rennie and Mairead Dunne's publications relating to the results are in press or in preparation. Interesting findings from this study include the similarity between the perceptions of Fiji students about science and careers and those of students in other countries where related work has been carried out.

As a co-researcher in an ARC-funded project, entitled Gender Reform in Schools: The Reception and

Effects of Equal Opportunity Programs for Girls and led by Dr Sue Willis (Murdoch University) and Dr Jane Kenway (Deakin University), Léonie Rennie has been involved in a case study of the effectiveness of gender-related innovations in a Western Australian school. This project began in 1990 and continues into 1991.

Key Centre staff also focused during 1990 on a comprehensive international review of teacher professional development in the area of gender equity. Building on the paper developed by Lesley Parker and Léonie Rennie for the national *Discipline Review of Teacher Education in Mathematics and Science* (entitled 'Gender Issues in Science Education with Special Reference to Teacher Education'), further significant input in relation to this topic has been made in national and international forums; this is continuing in 1991.

Additional national and international research activities supported by the Key Centre during 1990 and 1991 relate to the Sixth International GASAT (Gender and Science and Technology) Conference held in Melbourne in July 1991. In fact, Key Centre staff played a major role in the organisation of this event, which involved nearly 200 people from 22 countries. Dr Léonie Rennie was Joint Convenor (with Gaell Hildebrand of the University of Melbourne) of this conference. Also the Key Centre was a major sponsor of the various books which are being published in association with the conference (edited by Léonie Rennie, Lesley Parker and Gaell Hildebrand). The first two of these volumes are described in Section 4.4 and Appendix D.

The Key Centre also supported the review of post-compulsory education in Sweden conducted by Associate Professor Lesley Parker, focusing on education-industry links and gender equity initiatives. The report of this review was launched publicly by the Minister for Education in Western Australia as a stimulus discussion paper on post-compulsory education.

A further innovative project, involving cooperation with teachers in a Western Australian school, was the evaluation of the implementation of a gender-inclusive course to teach mechanics to Year 8 students. Although there is now a number of curricula which claim to be gender-inclusive, there is little hard evidence to attest to their efficacy. This project was an important step towards establishing the success of these curricular initiatives. The Key Centre's involvement in the COMETS project (see section 7.1) is another example of an important contribution to a national curriculum effort.

Two publications on gender issues already have been written for the Key Centre's *What Research Says to the Science and Mathematics Teacher* series (see Section 4.2) and Key Centre staff are working on a book on gender issues in science and mathematics education (see Section 4.4 and Appendix D).

3.2 **Classroom Environment**

This research builds on a strong tradition of prior research on classroom environments (Fraser, 1986). Despite the uniqueness and importance of the laboratory setting in science teaching, hitherto no classroom environment instrument existed which was tailored to this specific setting. Consequently, research was undertaken to fill this gap and permit teachers to monitor and improve their laboratory-based teaching. In collaboration with Associate Professor Geoff Giddings in the Faculty of Education at Curtin and Dr Campbell McRobbie of the Centre for Mathematics and Science Education at Queensland University of Technology, Professor Fraser is involved in the development, validation and application of a new questionnaire specially suited to laboratory classes at the senior high school and university levels. Among other questions, gender differences in student perceptions of actual and preferred environment are being explored. The study involved a sample of over 5 000 students from six countries. Funding support of approximately $57 000 for this work was awarded by the Australian Research Council (ARC) for 1990 and 1991, and a paper based on this work was awarded the Outstanding Paper Award in 1991 by the Special Interest Group on the Study of Learning Environments of the American Educational Research Association.

Research on students' perceptions of classroom environment is being extended to investigations of teachers' perceptions of school climate. In this work, Professor Fraser is collaborating with Associate Professor Darrell Fisher of the University of Tasmania at Launceston.

During a visit to Curtin University in March-April 1990, Professor Theo Wubbels of the University of Utrecht in The Netherlands collaborated with Professor Fraser in a study relating student perceptions of teacher interactional behaviour with teacher perceptions of school climate. Australian data are being compared with research conducted in The Netherlands and the USA.

The topic of classroom environment has been the subject of two Key Centre publications. 'Assessing and Improving Classroom Environment' is No. 1 in the *What Research Says to the Science and Mathematics Teacher* series and 'Environments for Learning Science and Mathematics' is *Key Centre Monograph No. 2* (see Section 4.2 and 4.3). Recently Professor Fraser coedited with Professor Herbert Walberg of the University of Illinois a book entitled *Educational Environments: Evaluation, Antecedents and Consequences*, which was published in the UK by Pergamon Press in 1991.

3.3 Upper Secondary School Enrolment Patterns

Enrolment patterns in science and mathematics around Australia are of national concern because of low overall participation rates and marked gender differences in enrolment patterns. Curtin staff previously reported a comprehensive study of enrolment patterns (Dekkers, de Laeter & Malone, 1986), which has been cited widely in state and national reports and whose value has been acknowledged by the Federal government. Recently Associate Professor John Malone collaborated with others in collecting more recent enrolment data for upper secondary school science and mathematics subjects. Gender differences in enrolment patterns again were a major focus. *Key Centre monograph No. 4* (see Section 4.3) draws on this research to present an analysis of enrolment patterns in science, mathematics and computing around Australia.

3.4 Aboriginal Students: Bridging Programs in Science/Mathematics and Research on Participation and Achievement in Mathematics

In an attempt to increase the participation of Aborigines in Curtin's science-related undergraduate courses, the Science and Mathematics Education Centre and the Centre for Aboriginal Studies undertook a curriculum development project funded by the Commonwealth Tertiary Education Commission's Equity Program. Bridging programs for second-chance Aboriginal students in mathematics and chemistry were successfully developed, trialled and evaluated (Taylor *et al.*, 1989; Fraser *et al.*, 1990). In 1989, the Key Centre initiated a revision of the programs for use by secondary schools and other tertiary education institutions wishing to provide bridging programs for second-chance students, including mature-age women, and students from non-English speaking and low socioeconomic backgrounds. A special brochure was designed and distributed to all secondary schools, colleges of advanced education and universities throughout Australia. A copy of the advertising brochure for the bridging programs is provided as Attachment 10 in the Supplement to this report.

Commencing in 1989, under a grant of approximately $38 000 from the Australian Research Council, Associate Professor John Malone and Mr Peter Taylor were involved in a research study which extended the work on bridging programs by examining mathematics learning among Aboriginal students at the secondary school level (i.e., the feeder group for the bridging program). This study was aimed at identifying classroom, school and social factors which adversely affect Aboriginal students' attitudes, motivation and achievement in mathematics at the Year 8-10 levels. Data collection techniques included classroom observation, interviews with students, teachers and parents, document analysis and questionnaire survey. As this research involved the use of classroom environment instruments, it also is linked with the Key Centre's research thrust involving classroom environment and described in Section 3.2.

Factors which were found to affect attitudes and achievement adversely include: school policies which sometimes overlook Aboriginal children's needs for bicultural education; classroom teaching that for one reason or another sometimes fails to provide due regard for Aboriginal children's individual abilities, learning needs and future aspirations; a 'cultural-communications' barrier between the school and home that sometimes prevents a well-informed cooperative approach to resolving student problems; and the high absentee rate among Aboriginal students that severely hampers continuity of conceptual development in daily lessons.

During 1990, Associate Professor John Malone and Dr Diane Miller continued this line of research by examining secondary students' understanding of basic mathematics vocabulary used routinely in the instructional process and in textbooks. Data have been collected from approximately 2 400 Year 8-11 students from 12 secondary schools in the Perth suburbs and in rural areas in north Western Australia and Alice Springs. One research question being explored is whether a difference in the understanding of basic mathematical terms exists between Aboriginal and non-Aboriginal students. Data analysis is continuing in 1991.

3.5 Factors Linked with Student Achievement: Secondary Analysis of National Data Base

Key Centre staff are attempting, first, to identify through educational research those factors which are linked empirically with student learning and, secondly, to disseminate these findings to teachers so that they can change their teaching to optimise factors likely to enhance student performance. Currently, Professor Fraser is collaborating with various colleagues, including Dr Malcolm Rosier of the Australian Council for Educational Research in Melbourne, in analysing the massive national data base collected as part of the Second International Science Study (SISS) for this purpose (Fraser, Walberg, Welch & Hattie, 1987). For the two-year period 1989-90, the Australian Research Council (ARC) provided Professor Fraser with a grant of approximately $49 000 to support this research.

This line of research is being continued over a three-year period commencing in mid-1991 when Ms Deidra Young took up an ARC Postdoctoral Research Fellowship to pursue various secondary analyses of the data from the SISS and the Second International Mathematics Study (SIMS) under Professor Fraser's supervision. The total value of the Fellowship is approximately $130 000.

Associate Professor Geoff Giddings (top) involved in research with overseas visiting scholars, Dr Linda DeTure (left) and Professor Rod Doran (right)

In September and October 1989, Professor Rod Doran of the State University of New York visited Perth to collaborate with Key Centre staff, Professor Barry Fraser and Dr Geoff Giddings, and Dr Linda DeTure (a visitor from Florida), in administering SISS laboratory practical tests in Western Australia and comparing data with other countries. Gender differences in laboratory performance were explored, as were factors linked with better performance on laboratory tasks. A symposium based on this work was presented by Giddings, Fraser, Doran and DeTure at the annual meeting of the National Association for Research in Science Teaching in Wisconsin in April 1991.

3.6 Learning and Teaching of Science/ Mathematics

An important research thrust of the Key Centre involves investigation of how teachers help students construct their own knowledge. Associate Professor David Treagust, Mr Peter Taylor, colleagues and research students are investigating the influence of teacher content knowledge and pedagogical content knowledge on the manner in which teachers facilitate learning for students.

During the second half of 1988, Associate Professor Treagust collaborated with three overseas visitors (Professor Ivo Lindauer of the University of Northern Colorado, Professor Paul Joslin of Drake University, Iowa and Professor Reinders Duit of the University of Kiel, Germany) in a study of teachers' use of analogies. During 1989, papers based on this research were presented by David Treagust at the annual conference of the Australian Science Education Research Association in Melbourne and by Reinders Duit at the annual conference of the equivalent association — Gesellshaft für die Didaktik der Chemie und Physik (GDCP) — in West Germany. A grant for approximately $100 000 was obtained by Associate Professor Treagust from the ARC for 1991-94 to pursue further research on teachers' use of analogies.

Other Key Centre staff pursuing this line of research are Dr Diane Miller and Associate Professor John Malone, who are co-recipients of a 1991 Small Grant from the Australian Research Council. They are investigating the use of writing to facilitate the construction of teachers' pedagogical content knowledge in secondary mathematics. This study is a continuation of research conducted by Dr Miller in the United States and initiated in Australia during 1990.

Currently, Key Centre staff, David Treagust and Barry Fraser, are editing a book on the teaching and learning of science and mathematics with Reinders Duit from Germany (see Section 4.4).

3.7 Constructivist Styles of Teaching and Learning

Peter Taylor is investigating the influence of beliefs on secondary school mathematics teachers' conceptualisations of their classroom roles and their personal theories of knowing as they undertake collaborative, classroom-based research aimed at developing 'constructivist' styles of teaching. A specific focus of the research is the development of an instrument for measuring the extent to which students perceive that their teacher actively creates a constructivist classroom environment. Mr Taylor is collaborating with Professor Barry Fraser in the development, field testing and validation of the Constructivist Classroom Environment Survey (CLES). This work, which is relevant to the research thrust described in Section 3.2, was reported in the USA in April 1991 at the annual meetings of the American Educational Research Association and the National Association for Research in Science Teaching (Taylor & Fraser, 1991).

3.8 Postgraduate Students' Research

As Section 2.5 and Appendices A and B show, a vast amount of research in science and mathematics education is being carried out by Curtin's postgraduate students. For example, 24 PhD theses are now in progress and as many as 71 Master's projects or theses are either currently in progress or were completed in 1989 and 1990.

4. PUBLICATION PROGRAM

4.1 Key Centre *News-sheets*

During June and December, 1989, the Key Centre instigated its first two *News-sheets* (Nos. 1 and 2) as a major vehicle of national communication with science and mathematics teachers throughout Australia. *News-sheets* Nos. 3 and 4 were published, respectively, in June and December, 1990. The latest *News-sheet* (No. 5) appeared in June 1991. These brief, attractive publications carry information about many of the Key Centre's activities including its postgraduate programs (e.g., new units and opportunities for study during school holidays); its publications, including the *What Research Says* series; Key Centre staff's involvement in national and state science and mathematics teachers' association conferences; professional development institutes being offered; new staff and visitors to the Key Centre; and research in progress. Several copies of each *News-sheet* were sent to the Head of Science and Head of Mathematics in each of the approximately 2 500 secondary schools in Australia with a request that the copies be shared with teachers. *News-sheets* Nos. 1-5 are provided as Attachment 11 in the Supplement to this report.

4.2 *What Research Says to the Science and Mathematics Teacher* Series

The Supplement to this report (Attachments 12 and 13) contains two of the first seven publications in this series, which aims to bring the results of important research endeavours to the attention of science and mathematics teachers. In order to appeal to busy teachers, these publications are relatively brief, avoid jargon and are produced in an attractive format. Two free copies of these publications were sent to every secondary school in Australia, with one copy going to the Head of Science and the other going to the Head of Mathematic (i.e., a total of approximately 5 000 copies were distributed to 2 500 schools). The seven titles that were distributed to schools in 1989 and 1990 are:

No. 1 *Exemplary Science and Mathematics Teachers* (Barry Fraser, Curtin University and Kenneth Tobin, Florida State University)

No. 2 *Assessing and Improving Classroom Environment* (Barry Fraser, Curtin University)

No. 3 *Scientific Diagrams: Can Students Read Them?* (Richard Lowe, Murdoch University)

No. 4 *Images of Scientists: Gender Issues in Science Classrooms* (Jane Kahle, Miami University, USA)

No. 5 *Metaphors and Images in Teaching* (Kenneth Tobin, Florida State University)

No. 6 *Gender Equality in Science Classrooms* (Svein Sjøberg, University of Oslo, Norway)

No. 7 *Target Students* (Kenneth Tobin, Florida State University).

4.3 *Key Centre Monographs*

In addition to relatively brief publications in the *What Research Says to the Science and Mathematics Teacher* series, the Key Centre sponsors the publication of more comprehensive monograph-length publications for teachers and science/mathematics educators. Sometimes these monographs provide more in-depth follow-up to material covered in *What Research Says* publications. The following four *Key Centre Monographs* appeared in 1991.

No. 1 *Barriers to Learning Science with Understanding* (by Kenneth Tobin, Florida State University, Barry Fraser and Léonie Rennie, Curtin University). This monograph describes a study of problems associated with higher-level cognitive learning.

No. 2 *Environments for Learning Science and Mathematics* (by Barry Fraser, Curtin University, and Kenneth Tobin, Florida State University). This publication draws on several studies which combined ethnographic methods and questionnaire surveys.

No. 3 *Learning in Science Viewed as Personal Construction: An Australasian Perspective* (Edited by Jeff Northfield, Monash University, and David Symington, Victoria College). This monograph contains five chapters which draw on relevant material from papers presented at annual conferences of the Australasian Science Education Research Association.

No. 4 *Upper Secondary School Science and Mathematics Enrolment Patterns in Australia, 1970-1989* (John Dekkers, University College of Central Queensland, and John de Laeter and John Malone, Curtin University). This monograph reports the collection and analysis of recent information on upper secondary school enrolment patterns in science and mathematics throughout Australia.

An advertisement for these monographs (see Attachment 14 in the Supplement to this report) was distributed to the Heads of Science and Mathematics in every secondary school in Australia. An example of one of the monographs is provided as Attachment 15 in the Supplement.

4.4 Books Relevant to the Key Centre's Areas of Research Focus

Key Centre staff recently have been or currently are involved in the editing of eight books of readings covering research areas germane to the work of the Key Centre (see Section 3). Every book contains a sizeable proportion of Australian content and is well-suited for use among Australian science/mathematics teachers and Australian science/mathematics educators involved in the preservice and inservice education of teachers. However, as all books cover topics that are internationally significant, most of the books also include chapters authored by overseas people. In this way, Key Centre staff are making a major contribution to science/mathematics education globally and are earning considerable international visibility and kudos for the Key Centre. The eight books are described briefly below:

- *Exemplary Practice in Science and Mathematics Education* (Edited by Kenneth Tobin, Florida State University, and Barry Fraser, Curtin University; published in a second edition by the Key Centre in 1989). This book reports 13 researchers' case studies of 23 Australian teachers nominated by their peers as exemplary science or mathematics teachers and the Year 1-12 levels. Appendix D provides an overview of the book's 14 chapters.

- *The Mathematics Curriculum: Towards the Year 2000* (Edited by John Malone, Curtin University, Hugh Burkhardt, University of Nottingham, and Christine Kietel, Technische University, Berlin; proceedings of the Sixth International Congress on Mathematical Education, Budapest, 1988; published by Curtin University in 1989). This 469-page book contains 60 papers, written by 65 authors from around the world, which are related to the theme of 'the mathematics curriculum' and which were presented at this conference. For the sake of brevity, only the major section headings from the book's table of contents are included in Appendix D.

- *Windows into Science Classrooms: A Study of Higher-Level Cognitive Learning in Science* (Edited by Kenneth Tobin, Florida State University, Jane Butler Kahle, Miami University, Ohio, and Barry Fraser, Curtin University; published by Falmer Press in London in 1990). This book is based on an Australian study of the barriers which prevent higher-level cognitive learning occurring in secondary school science classrooms. Appendix D lists this book's table of contents.

- *Environments for Learning: Evaluation, Antecedents and Consequences* (Edited by Barry Fraser, Curtin University, and Herbert Walberg, University of Illinois; published by Pergamon Press in Oxford in 1991). This book provides 15 chapters dealing with assessing, improving and investigating the learning environments of classrooms and schools. Appendix D contains this book's table of contents.

- *Gender, Science and Mathematics: Shortening the Shadow* (Edited by Lesley Parker, Léonie Rennie and Barry Fraser, Curtin University; currently in preparation). The 17 chapters in this book aim to enhance understanding of gender issues in science and mathematics education and to suggest tangible ways of reducing gender inequities in classroom processes, enrolment patterns and student achievement. The contents of this book are listed in Appendix D.

- *Teaching and Learning in Science and Mathematics* (Edited by David Treagust, Curtin University, Reinders Duit, University of Kiel, and Barry Fraser, Curtin University; currently in preparation). This book contains a total of 24 chapters on the theme of improving teaching and learning and arranged into three sections, namely, investigating student understanding, improving curriculum and teaching, and implementing teacher change. See Appendix D for the title and author of each chapter.

- *Improving Science Education: What Do We Know?* (Edited by Barry Fraser, Curtin University, and Herbert Walberg, University of Illinois; commissioned by the International Academy of Education; currently in preparation). This book contains 10 chapters which aim to provide decision-makers with research-based advice to guide the improvement of science education. Appendix D contains this book's table of contents.

- *Action for Equity: The Second Decade* (Edited by Léonie Rennie and Lesley Parker, Curtin University, and Gaell Hildebrand, University of Melbourne; published by the Key Centre in 1991). This is a two-volume set of contributions to the Sixth International GASAT (Gender and Science and Technology) Conference held in Melbourne in 1991. Over 130 authors from 20 different countries are represented in the contributions. Appendix D provides an overview of the contents of the two volumes.

4.5 Videotape Resources

The Key Centre has sponsored the production of four videotapes:

- *Girls Learning Science: Promoting a Gender-Inclusive Science Curriculum* is a joint project of the Science Teachers' Association of Western Australia (STAWA) and the Key Centre. The production of the 30-minute tape was coordinated by Léonie Rennie and Ms Shelley Yeo (the Equity Officer of STAWA and Head of Science at St Mary's Anglican School for Girls) in consultation with Associate Professor Colin Latchem (Head of the Educational Media Centre, Curtin University) and a number of teachers in schools. The tape is hosted by a professional television presenter and comprises a mix of short statements/interviews with teachers and students and classroom vignettes which raise issues regarding the gender-inclusive curriculum and gender-inclusive teaching strategies. It is accompanied by teachers' notes and other learning materials. The tape is being distributed on a cost-recovery basis (in VHS cassette form). It was broadcast in Western Australia by the GWN (Golden West Network) television station on March 25, 1991, and will be broadcast nationally on the educational service provided by the SBS. A flyer advertising this videotape was mailed to every secondary school throughout Australia (see Attachment 16 in the Supplement).

- *Of Sex, Schooling and Science: Perceptions of the Effects of Mixed and Same Sex Educational Environments* (provisional title) is being coordinated by Lesley Parker and Léonie Rennie, in association with Curtin's Educational Media Centre. The 30-minute tape features interviews with people who have considered in some depth the effects of coeducational and single-sex schooling on girls' and boys' science education, including Dr Jan Harding (UK, Equal Opportunities Consultant), Dr Sue Willis (Coordinator of the Australian Government's program for Gender Equity in Science and Mathematics) and principals and teachers from all-girl, all-boy and mixed sex schools. The tape will be completed in 1991 and disseminated nationally and internationally through cassettes and broadcast.

- *Talking About Talk: The Gendering of Social Interaction in Science and Mathematics Classrooms.* This videotape focuses on sexism in language and social interaction . It is based on an interview with Dr Dale Spender, an Australian author and researcher. She is questioned about her extensive research in the area of language, in terms of general human interaction, and about the consequences for classroom interaction of sex roles and power play which underlie our current social norms. Dr Spender's comments are interspersed with reactions from practising science and mathematics teachers. The videotape, accompanied by a reading list and notes to focus discussion, will be completed and disseminated widely in 1991.

- *Complex Numbers: The Euler Relation*, a 35-minute videotape supported by a guide and teacher's handbook, was completed in 1990 and is currently available for distribution. Staff from the Key Centre collaborated with Visuwell Systems in the production of this videotape. All material is suitable for classroom use, either directly or in the form of a student project. The video guide summarises each scene and adds historical and technical comments wherever appropriate. The teacher's handbook describes the essential properties of complex numbers and the rules for their manipulation and geometric display. Numerous worked examples and applications are included as well as a number of student projects and investigations. A flyer announcing the availability of the video and describing it in greater detail has been sent to the Head of Mathematics in every secondary school in Australia (see Attachment 17 in the Supplement).

5. FACE-TO-FACE CONTACT WITH TEACHERS

Creating opportunities for face-to-face interaction between science and mathematics teachers and Key Centre staff is considered to be a most important thrust of the Key Centre's work. But, given the national character of the Key Centre, organising this face-to-face contact with teachers from around Australia is not a simple matter.

As an alternative to the Key Centre organising its own opportunities to meet face-to-face with teachers, staff attendance at national and state science/mathematics teachers' conferences provides efficient and convenient access to large gatherings of teachers. These conferences provide an opportunity for Key Centre staff to:

- present numerous workshops and talks, including presentations focussing on the work of the Key Centre (see Section 5.1);
- exhibit a display in the exhibitors' area (see Section 5.2);
- make the expertise of some of its eminent overseas visitors available (see Section 5.3);
- offer additional professional development opportunities for teachers in collaboration with other organisations or associations (see Section 5.4).

The second major way of arranging face-to-face contact with teachers has involved the Key Centre in mounting a unique series of professional development 'institutes', mostly led by international experts and held at Curtin University during the school holidays. These provide a way of providing a relatively limited number of teachers with an opportunity to pursue concentrated, in-depth activities (see Section 5.5).

In 1990 and 1991, several initiatives involving face-to-face contact between Key Centre staff and Heads of science and mathematics departments in local high schools around Perth were implemented (Section 5.6).

5.1 Key Centre Staff Presentations at Conferences of Science and Mathematics Teachers

Below are listed the 71 presentations made by Key Centre staff and visitors at 14 science or mathematics teachers' conferences held during 1989, 1990 and 1991.

Conference of Australian Science Teachers' Association (CONASTA), Melbourne, July 1989

- Assessment and Improvement of Classroom Environment (Barry Fraser and Geoff Giddings)
- A New Questionnaire for Assessing Science Laboratory Classroom Environments (Barry Fraser and Geoff Giddings)
- A Study of Exemplary Science and Mathematics Teachers (Barry Fraser and David Treagust)
- Overview of Activities of the National Key Centre for School Science and Mathematics (Barry Fraser)
- Fair and Equitable Assessment of Boys and Girls in Science: Issues and Practical Problems (Léonie Rennie and Lesley Parker)
- The Physics of Technological Systems: Encouraging Poor Achievers to Learn Physics (Menahem Finegold; Curtin overseas visitor)
- How to Publish Your Ideas and Work in the *Australian Science Teachers' Journal* (David Treagust)
- Enrolment and Performance of Girls in Science in Unit Curriculum: Portents for the Future (Léonie Rennie and Lesley Parker)
- Learning About Forces: Simulating the Application of Students' Perceptions of Forces Acting in Simple Physical Systems (Menahem Finegold; Curtin overseas visitor)
- Teaching Elementary and Secondary Science (Howard Birnie; Curtin overseas visitor)
- Use of Diagnostic Tests (David Treagust).

Conference of Mathematical Association of Victoria (MAV), Melbourne, December 1989

- Aboriginal Participation in Secondary Mathematics (Peter Taylor and John Malone)
- The National Key Centre for Teaching and Research in School Science and Mathematics: An Overview of Activities (John Malone)
- Exemplary Mathematics Teachers (John Malone and Peter Taylor)
- The Influence of a Teacher's Beliefs on Teaching Practice (Peter Taylor).

Conference of Science Teachers' Association of Victoria (STAV), Melbourne, December 1989

- Introduction to Key Centre for School Science and Mathematics (Barry Fraser)
- Assessing and Improving Science Classroom Environments (Geoff Giddings and Barry Fraser)
- Research on Exemplary Science Teachers (Barry Fraser)
- Assessment of Practical Performance in Science Laboratories (Rodney Doran, Geoff Giddings and Barry Fraser).

Conference of Australian Science Teachers' Association (CONASTA), Alice Springs, July 1990

The Key Centre made available one of its eminent overseas visitors, Professor Jane Butler Kahle of Miami University in Ohio, USA (a world leader in the area of girls in science), to present a keynote address and to run a whole-day mini-course during this conference.

- Excellence and Equity in Science Education (Jane Butler Kahle, Key Centre visitor; keynote address);
- Teachers as Researchers: Gender Equity in the Classroom (Jane Butler Kahle and Léonie Rennie; mini-course)
- Assessment and Evaluation in the Science Laboratory (Geoff Giddings)
- New Initiatives of the Key Centre (Geoff Giddings and Léonie Rennie)
- Gender-Inclusive Strategies in Science (Léonie Rennie *et al.*)
- Science Learning in Culturally Diverse Settings (Mairead Dunne and Olu Jegede).

Conference of the Australian Association of Mathematics Teachers (AAMT), Hobart, July 1990

- Writing to Learn Mathematics (Diane Miller)
- Australia's Key Centre for Mathematics and Science Teaching (John Malone)
- International Comparisons in Mathematics Education (John Malone and Barry Kissane)
- How Secondary School Students Learn Mathematics (Khoon Yoong Wong)
- Process or Product? Constructivism in School Mathematics (Jayne Johnston and Mairead Dunne)
- Humanising Calculus: Responses to a New Approach to Teaching Calculus (Mary Barnes and Jayne Johnston).

Conference of the South Australian Science Teachers' Association (SASTA), Adelaide, July 1990

Professor Barry Fraser was invited to present a keynote address at this conference based on his research on exemplary teachers.

- What Have We Learned from Research on Exemplary Science Teachers? (Barry Fraser; invited keynote address)
- Classroom Climate: Its Assessment and Importance in Science Teaching (Barry Fraser)
- Professional Development Opportunities Offered by National Key Centre (Barry Fraser and David Treagust)
- Diagnosing Student Conceptions and Teaching for Conceptual Change (David Treagust).

Conference of the Science Teachers' Association of New South Wales (STANSW), Sydney, September 1990

Dr Léonie Rennie presented an invited keynote address on her work on technology education at this conference.

- Science, Technology and Gender: Confronting the Issues (Léonie Rennie; invited keynote address)
- Technology in the Primary and Secondary School: Why Science Should Play a Leading Role (Léonie Rennie).

Conference of Mathematical Association of Western Australia (MAWA), Mandurah, May 1990

- Complex Numbers in the Year 12 Syllabus (John Malone)
- The Key Centre for School Science and Mathematics: A Centre for Teachers (John Malone and Diane Miller)
- Developing a Feeling for Fractions (Tom Kandl, Key Centre visitor)
- Using Mathematics-Science Teaching Specialists in Years 4 and 5 (Diane Miller)
- Doing Geometric Transformations with Logo (Khoon Yoong Wong)
- Humanising Calculus (Jayne Johnston *et al.*)
- Doing Mathematics (Jayne Johnston and Barry Kissane)
- International Comparisons in Mathematics Education (Jayne Johnston and Barry Kissane)
- Learning Mathematics (Jayne Johnston *et al.*).

Conference of Science Teachers' Association of Western Australia, Muresk, May 1990

- Tinkering with Gadgets (Léonie Rennie *et al.*)
- COMETS-Australia – Collaborative Curriculum in Action (Léonie Rennie and Mairead Dunne)
- Integrating Technology Education in the Science Curriculum (Léonie Rennie and David Treagust).

Conference of Science Teachers' Association of Victoria (STAV), Melbourne, December 1990

At this conference, the Key Centre made one of its overseas visitors available to STAV to act as a keynote speaker. The visitor was Dr Jan Harding, a consultant for Equal Opportunities in Science and Technology in the UK.

- Are you a Gender Bender? (Jan Harding, Key Centre visitor; keynote address)
- Skills, Knowledge and Issues: Alternative Starting Points for Presenting Topics in Science and Technology (Jan Harding and Léonie Rennie)
- Professional Development Opportunities Offered by the National Key Centre for School Science and Mathematics (Barry Fraser and Léonie Rennie).

Conference of Mathematical Association of Victoria (MAV), Melbourne, December 1990

Key Centre visitor, Dr Jan Harding, also delivered a keynote address at this conference.

- What Counts in Mathematics: A view from a Gender Perspective (Dr Jan Harding, Key Centre visitor; keynote address)

- Mathematics in Work: In Reference to Traditional Women's Work (Dr Jan Harding, Key Centre visitor)

- Teaching Complex Numbers (John Malone)

- The Impact of School Assessed Subjects on Year 12 Mathematics Enrolments in Australia (John Malone)

- Test-Item Format — Does It Make a Difference? (John Malone)

- The Key Centre for School Science and Mathematics: Provisions for Professional Development (Barry Fraser and Diane Miller)

- Writing to Learn Mathematics: Suggestions for Classroom Implementation (Diane Miller)

- Humanising Calculus: A Workshop and Evaluation Report (Jayne Johnston, Mary Barnes and Sue Wettenhall).

Conference of Australian Science Teachers' Asssociation (CONASTA), Adelaide, July 1991

- A Science Educator's Perspective on Literacy (Lesley Parker)

- Old Problem — New Ideas (Shelley Yeo and Susan Stocklmayer).

Conference of Mathematical Association of Western Australia (MAWA), Bunbury, May 1991

- Paper Engineering as a Mathematical Enrichment Activity (John Malone)

- Teacher Benefits from Students' Writing in Secondary Mathematics (Diane Miller)

Conference of Science Teachers' Association of Western Australia, Muresk, May 1991

- Teachers-as-Researchers: Towards Student-Centred Teaching (Peter Taylor)

- Concept Mapping for Meaningful Learning in Science (Peter Okebukola)

- What do Successful TEE Physics Students Know about Electricity and Mechancis? (Craig Adams, Mario Zadnick and David Treagust)

- The Teaching and Evaluation of Scientific Processes (Alan Griffiths)

- The Use of Analogies in Science Education (Rodney Thiele and David Treagust)

- Teaching Technology as a Design Process (David Treagust, Léonie Rennie and Adrianne Kinnear)

- Learning Science — Promoting Gender Equity in the Science Curriculum (Léonie Rennie).

5.2 Key Centre Display in Exhibitors' Area at Teacher Conferences

A display promoting the Key Centre was exhibited at each of the state and national conferences of science and mathematics teachers listed above. A series of items, prepared by the Educational Media Centre at Curtin University of Technology, were displayed in the exhibitors' area at each conference site. The display takes the form of a set of moveable panels that can be arranged to present a number of important aspects of the work of the Key Centre. These include a series of high quality photographs, graphics and textual panels covering the following areas: location of the Key Centre; staff associated with the Key Centre; postgraduate courses offered by the Key Centre; current research activities of the Key Centre; overseas visitors; specific research projects; professional development institutes offered by the Key Centre; and Key Centre publications. The display can be set up specifically to provide relevant information for either a mathematics or science teachers' conference. The display is updated regularly to reflect the most recent activities and research carried out by the Key Centre.

The display stands (usually three panels) are augmented by tables which have a range of the Key Centre's publications available for perusal, collection or purchase. Key Centre staff are in attendance at the stand throughout each conference. Overall, the Key Centre display has proved to be a particularly effective mechanism for the Centre to reach large numbers of teachers, educators and consultants, in a relaxed yet informative environment.

In addition to the display and publications in the exhibitor's area, the latest *News-sheet* and other information, advertisements and publications from the Key Centre are placed in participants' conference folders.

5.3 Making the Key Centre's Overseas Visitors Accessible at Teachers' Conferences

A unique service which the Key Centre has provided to national and state gatherings of teachers is that it has made available the expertise of some of its eminent overseas visitors. As indicated above, the Key Centre made it possible for Professor Jane Butler Kahle to present a keynote address on gender issues in science education at the annual conference of the Australian Science Teachers' Association in July 1990, and for Dr Jan Harding to present a keynote address at the conferences of both the Science Teachers' Association of Victoria and the Mathematical Association of Victoria in December 1990. As well, at the conference of the Science

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Key Centre display at teachers' conferences

Teachers' Association of Victoria, Professor Rodney Doran from the State University of New York made a presentation on assessing practical performance in science laboratories; this drew on both Professor Doran's extensive research in the USA and on data collected in Western Australia in collaboration with Professor Barry Fraser and Associate Professor Geoff Giddings.

5.4 Collaboration with other Organisations/Associations in Offering Teacher Professional Development Opportunities

Another way in which the Key Centre can organise professional development opportunities for teachers is by collaborating with other organisations or associations in jointly sponsoring such activities. This collaboration is especially useful for interstate penetration, and it sometimes can be organised in conjunction with teachers' conferences.

For example, Key Centre visitor, Dr Jan Harding, worked collaborately with the McClintock Collective in Melbourne (a national teacher network which promotes gender-inclusive science teaching) in offering a workshop on gender issues around the time of the conferences of the Science Teachers' Association of Victoria and the Mathematical Association of Victoria held in Melbourne in December 1990.

Another example of collaboration is the way that the Key Centre joined forces with three universities in making Key Centre visitors from overseas available to present workshops to teachers in other States. The Key Centre collaborated with the University of Technology, Sydney (UTS) in offering a two-day workshop on gender issues in science and mathematics education in Sydney in July 1990. This workshop was led by a Key Centre visitor, Professor Jane Butler Kahle of Miami University, Ohio, USA, and was based on a one-week 'institute' on the same topic sponsored by the Key Centre and described below (Section 5.5). A similar workshop, jointly sponsored by the Key Centre and the Center for Mathematics and Science Education at Queensland University of Technology, was presented by Professor Kahle to 85 participants in Brisbane in July 1991.

Similarly, in Sydney in September 1990, Professor James Gallagher of Michigan State University, presented to 65 teachers a half-day workshop based on the institute on teaching for understanding (see below) which he presented in Perth; this involved collaboration with the Australian Catholic University in Sydney. In addition, he presented talks/workshops to 35 undergraduate students from the Australian Catholic University and to 30 science and mathematics educators from various universities around Sydney.

5.5 Professional Development Institutes

An important Key Centre initiative for Australian teacher inservice education has been the introduction of professional development institutes led by eminent overseas experts and offered during school holidays. The institutes are designed to provide opportunities for teachers of secondary science and mathematics to develop practical strategies for improving their students' learning. Each institute has a teacher-as-researcher focus which helps teachers to review their teaching methodologies and prepares them for conducting practical research in their own classrooms. As well, the institutes provide teachers with useful ideas and materials which they can share with their colleagues in their own schools and regions.

One of the unique features of the institutes is that they may contribute as credit towards Curtin's postgraduate qualifications in science and mathematics education. Teachers who use the institutes to gain credit towards a unit in a Curtin University postgraduate program undertake written assignments in the external studies mode after attending the institute. All participants receive one of the specially designed certificates of attendance shown as Attachment 18 in the Supplement to this report.

A series of six one-week institutes already have been offered in the school holidays during 1990 and 1991, and another is planned for October 1991:

- *Constructivist Teaching and Learning Approaches*, led by Professor Kenneth Tobin of Florida State University, and assisted by Mr Peter Taylor of the Key Centre, was offered in the summer school holidays in 1990. This institute's main foci were the promotion of learning with understanding and the important role of students' prior knowledge and social interactions in the construction of scientific and mathematical concepts. The program comprised morning and afternoon seminars and workshops which addressed important issues in science and mathematics education. Participants analysed specially recorded videotapes of classroom teaching made in local Perth high schools, and planned classroom-based research projects for implementation on their return to schools. A total of 14 science and mathematics teachers and teacher educators from Victoria, South Australia, Western Australia and Papua New Guinea successfully completed this institute. Six of the participants enrolled for credit and undertook post-institute distance education studies at Curtin.

Professor Ken Tobin leading a professional development institute

- *Activating Science and Mathematics Students* was an institute in January 1990 to be led by Professor Tom Good of the University of Missouri, Columbia, USA. However, because of visa problems, Professor Good had to cancel his trip at short notice. Consequently, Dr Diane Miller, Senior Research Fellow in the Key Centre, and other Curtin staff led this institute. The institute focused on improving teacher and student performance by addressing important social dimensions of human communication in the classroom. Seminars and workshops addressed: teacher expectations and how they are formed and communicated to students in the classroom; instruments for measuring classroom climates and student perceptions; instruments for measuring students' attitudes and anxieties towards mathematics; strategies for improving whole-group and small-group instruction; and how to plan and implement classroom-based research in schools. A total of 15 science and mathematics teachers, teacher educators and administrators from the Northern Territory, Western Australia and Indonesia successfully completed all the requirements of the institute. Eight of the participants enrolled for credit by undertaking post-institute distance education studies towards the postgraduate programs.

- *Promoting Gender Equity in the Classroom*, led by Professor Jane Butler Kahle of Miami University, USA and assisted by Dr Léonie Rennie and Ms Jayne Johnston of the Key Centre, was offered in Juiy 1990. Participants in this institute explored issues related to gender in mathematics and science education, focusing particularly on understanding the influence of gender on factors determining patterns of enrolments, and on the kinds of action by teachers and schools which could decrease this influence. Prior to the institute, participants collected some initial data from their own classrooms for analysis on the first day. Post-institute activities, particularly for those attending for credit, included collecting some follow-up data, interviewing students and completing an ethnographic study of one science and mathematics classroom.

- *Teaching Science and Mathematics for Understanding and Application* was offered in October 1990 and was led by Professor James Gallagher of Michigan State University, with the assistance of Key Centre staff, Associate Professor David Treagust and Mr Peter Taylor. Research data show that the majority of secondary school students really do not understand, nor can they apply, the science and mathematics that is taught to them in school. Moreover, because students are so good at 'faking it', teachers often are unaware that so many of their students are only learning empty terms which do not help with understanding or application of the knowledge. Two major reasons for this disappointing state of affairs are, first, the lack of engagement by students in 'sense-making' activities which are needed to develop understanding of school science and mathematics and, second, the fact that testing rarely helps teachers uncover students' lack of understanding. This institute addressed both of these shortcomings. Prior to the institute, participants collected data from at least one class as a basis for the formulation of assessment procedures which uncover students' lack of understanding and inability to use the subject matter taught. Participants examined and practised teaching strategies that are useful in engaging all students in constructing meaning and developing understanding of science and mathematics.

- *Society and Technology in the Science Curriculum* was offered in January 1991 and led by Professor Alan Griffiths, Head, Department of Curriculum and Instruction, Memorial University of Newfoundland, Canada. Participants in this institute considered the development of science curricula which incorporated themes related to both society and technology, and undertook the development of curriculum units for use in their own teaching. Presentations, whole-group discussions, small-group discussion/activity sessions, and individual planning activities were among the instructional approaches used. Topics included science, technology and society, handling risk and controversy, pseudoscience, teachers as curriculum writers, and assessing students and evaluating curricula.

- *Teaching and Learning Mathematics: Contemporary Methodologies*, in January 1991, involved numerous mathematics educators, including Associate Professor John Malone, Dr Diane Miller, Dr Helen Mansfield and Ms Jayne Johnston from the Key Centre and Mr Barry Kissane from Murdoch University. Topics included national perspectives on curriculum reform, developing mathematical thinking, organising the classroom, the impact of technology, and teachers as researchers. Participants in this institute considered new directions in Australian mathematics curricula, especially the development of investigative and cooperative approaches in mathematics classrooms, and developed strategies for use in their own teaching. A total of 23 teachers attended. The Ministry of Education of WA made awards available to 13 of these teachers to cover the registration, travel and (if applicable) accommodation costs associated with participating in this institute.

- *Using Philosophy of Science and Mathematics to Improve Teaching* will be offered in October, 1991 by Professor Denis Phillips of Stanford University, with the assistance of Peter Taylor from the Key Centre. The institute will cover recent developments in the philosophy of science and mathematics and how these insights might be translated into classroom activities. Institute participants will be asked to bring their teaching syllabuses and examples of topics that might lend themselves to the pursuit of a deeper understanding of the nature of science or mathematics. During the afternoon sessions, participants will be assisted to plan for the development, trial and evaluation of teaching innovations on return to their own schools.

These institutes were advertised in the national press, in both Key Centre *News-sheets* and specially-designed brochures which were mailed to the Heads of Mathematics and Science departments at each of the 2 500 secondary schools throughout Australia. Examples of some advertising brochures for the institutes are contained in Attachments 4 and 5 in the Supplement to this report. As well, some institutes were advertised in science or mathematics teachers' journals or in special inserts to these journals.

5.6 Luncheons for Heads and Visits to Schools in Perth Area

Although the Key Centre's audience is primarily national in character, it was thought timely during 1990 to begin to develop a special relationship with Heads of Science and Mathematics in schools in the Perth area. Consequently, in August 1990, the Key Centre sponsored a luncheon at Curtin University Club for Heads of Science and another luncheon for Heads of Mathematics from government and private schools in Perth and the immediate geographical area. The purpose of these luncheons was to establish closer communication with local teachers so that the Key Centre could benefit from their advice about desirable future directions for the Key Centre and about possible ways in which it might provide support locally.

Professor John de Laeter, Deputy Vice-Chancellor for Research and Development at Curtin University, gave a brief address on teaching science/mathematics in the 1990s. Participants were presented with a brief overview of the Key Centre's purposes, activities, support systems and publications. Teachers completed a questionnaire soliciting suggestions for how the Key Centre could better serve the mathematics and science education community both locally and across the nation. Some of these suggestions already have evolved into plans of action for local schools.

One suggestion was for Key Centre staff to visit local schools to discuss the Key Centre with teachers. This suggestion was followed up and Key Centre staff accepted invitations to visit numerous local schools. These visits generally occurred after school hours or during the school day when the science and/or mathematics staff had a common planning period.

Further face-to-face contact between Key Centre staff and teachers in Western Australia occurred when Key Centre staff are invited to deliver keynote addresses and/or conduct workshops at district professional development meetings in country areas. Dr Diane Miller went to Bunbury in March 1991 to work with mathematics teachers at the meeting of the South West Mathematics Association. In May, she conducted three workshops at the Bunbury District's Professional Development Day and also travelled to Port Hedland to talk with mathematics teachers from several schools in the northern part of the state about the use of collaborative groups and the teaching of problem solving. She gave the keynote address at the Moora District Professional Development Day in July 1991.

Another suggestion was that Key Centre staff offer seminars for special groups (e.g., teachers teaching outside their primary area of preparation; women teachers; beginning teachers; Heads of Mathematics and Science). This suggestion has been followed up with the offering of the series of short courses described previously in Section 2.9.

6. SEMINAR SERIES

The Key Centre and SMEC jointly sponsor a seminar series for staff, students and teachers interested in science and mathematics education. Appendix C contains the six seminar programs offered between Semester 1, 1989 and Semester 2, 1991. All presentations in this series are available on videotape or audiotape to students undertaking Curtin's postgraduate programs in science and mathematics education by external study.

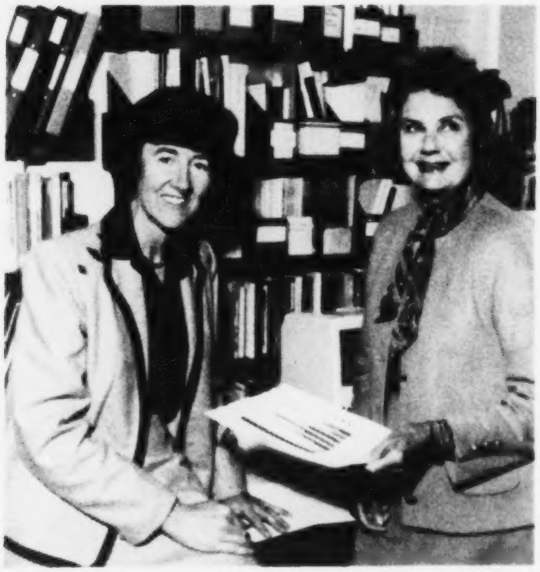
7. OVERSEAS CONSULTANTS AND VISITORS

7.1 Consultants on Gender Issues

The Key Centre has sponsored visits from several overseas visitors with recognised expertise in gender issues in science/mathematics education. These visitors provided advice on the Key Centre's activities related to gender issues and wrote material for the Key Centre's publication program. Details of these visitors and their activities are given below:

Key Centre's seminar series

- Dr Svein Sjøberg of the University of Oslo in Norway visited the Key Centre for approximately a month in June 1989. Dr Sjøberg wrote an issue of *What Research Says* devoted to gender issues (see Section 4.2) and provided advice on the Key Centre's work on gender issues.



Dr Léonie Rennie (left) with Professor Jane Butler Kahle, Key Centre consultant

- Professor Walter Smith of the University of Kansas visited the Key Centre for approximately a month in February-March 1990 to work with Léonie Rennie and Mairead Dunne on the COMETS (Career-Oriented Modules for Exploring Technology and Science) project. COMETS is an Australian curriculum project which developed teaching materials for students in Years 5 to 9. The philosophy underlying COMETS is that people in virtually all careers apply science profitably in their work. It aims to inform students about practical applications of science and technology studies and to encourage girls in science, mathematics and technology. COMETS originally was published by the National Science Teachers' Association in the USA. During his sabbatical leave in Australia, Professor Smith visited several Australian states to lead the Australian initiative. Teachers from Perth were involved in the writing of materials, which have an Australia-wide appeal. The visit of Professor Smith to the Key Centre was made possible through collaboration with the Science Shop in Melbourne.

- Professor Jane Butler Kahle, originally of Purdue University and now of Miami University in Ohio, visited the Key Centre twice as a consultant. During a one-month visit in July-August 1989, she offered advice

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about a gender issues book and a gender issues postgraduate unit in preparation, and completed the initial planning for an institute — Promoting Gender Equity in the Classroom — which she later offered during July 1990. Professor Kahle made a return visit to the Key Centre for about a month in July 1990. She was a keynote speaker at the annual conference of the Australian Science Teachers' Association held in Alice Springs, and she offered a conference workshop during the conference entitled 'Teachers as Researchers: Gender Equity in the Classroom'.

Common Threads

Associate Professor Lesley Parker (left) with Dr Jan Harding, Key Centre consultant

- Dr Jan Harding, Equal Opportunities Consultant from the UK, visited the Key Centre as a Consultant during November and December 1990, and again in August 1991. While based at Curtin University, Dr Harding provided advice to Key Centre staff, was interviewed for radio 6NR, worked on the writing of a chapter to be included in a book being edited by Key Centre staff, began writing a contribution for the *What Research Says to the Science and Mathematics Teacher* series, and acted as a consultant for a postgraduate unit on gender issues in science and mathematics education being prepared by the Key Centre. In particular, Dr Harding collaborated with Dr Léonie Rennie and Lesley Parker in scripting and recording a 15-minute interview on single-sex and coed-schooling for broadcasting on GWN educational television and for use in the postgraduate unit.

Dr Harding also represented the Key Centre in various activities in Melbourne in December 1990. She presented a workshop and an invited keynote address at the annual conferences of both the Science Teachers' Association of Victoria and the Mathematical Association of Victoria. On December 12-14, she worked with teachers at a three-day workshop on the writing of gender-inclusive science units for the Victorian Certificate of Education; this workshop was organised by the McClintock Collective (a national network of teachers aimed at promoting gender-inclusive teaching in science) in Melbourne and the State Equal Opportunity Resource Centre at Geelong. Dr Harding will make another visit to the Key Centre as a Consultant during August 1991.

7.2 Other Visitors

The Key Centre and/or SMEC sponsors numerous overseas and interstate visitors who provide advice on Key Centre activities, teach in postgraduate programs in science and mathematics education, participate in research, etc. Past visitors since mid-1988, current visitors and future visitors visiting for periods of up to six months' duration are listed below:

- Dr Reuven Lazarowitz, Technion Institute of Technology, Israel (February-October 1988)
- Professor Paul Joslin, Drake University, Iowa (July-December 1988)
- Professor Ivo Lindauer, University of Northern Colorado (July-December 1988)
- Dr Svein Sjøberg, University of Oslo (June 1989)
- Professor Walter Doyle, University of Arizona (August-September 1988)
- Professor Reinders Duit, University of Kiel (August-October 1988)
- Professor Howard Birnie, University of Saskatchewan (February-June 1989)
- Dr Menahem Finegold, Technion Institute of Technology, Israel (February-June 1989)
- Professor Ference Marton, University of Goteborg, Sweden (March 1989)
- Dr Ed van den Berg, Satya Wacana University, Indonesia (April 1989)
- Dr Diane Miller, Louisiana State University (May 1989)
- Professor Hugh Burkhardt, University of Nottingham (August 1989)
- Ms Rosemary Fraser, University of Nottingham (July-August 1989)
- Dr Malcolm Rosier (Australian Council for Educational Research, Melbourne, June 1989)
- Dr Avi Hofstein, Weizmann Institute of Science, Israel (August-September 1989)
- Dr Linda DeTure, Rollins College, Florida (October-November 1989)
- Professor Rod Doran, State University of New York (October-November 1989)

8

7

1

KEY CENTRE VISITORS

6

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3

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Clockwise: (1) Reinders Duit, University of Kiel, Germany; (2) Linda DeTure, Rollins College, Florida, USA; (3) Peter Okebukola, Lagos State University, Nigeria; (4) Reuven Lazarowitz, Technion Institute of Technology, Israel; (5) Rosemary Fraser, University of Nottinghham, UK; (6) Svein Sjøberg, University of Oslo, Norway; (7) Theo Wubbels, University of Utrecht, The Netherlands; (8) Alan Griffiths, Memorial University of Newfoundland, Canada.

- Professor Theo Wubbels, University of Utrecht, The Netherlands (March-April 1990)
- Dr Louise Gann, Tennessee (February-June, 1990)
- Dr Darrell Fisher, University of Tasmania, Launceston (March and December 1990; September 1991)
- Dr Joseph Menis, Bar Ilan University, Israel (July-August 1990)
- Professor James Gallagher, Michigan State University (September-October 1990)
- Professor Rob Walker, Deakin University (September-October 1990 & September-October 1991)
- Dr Jan Harding, Equal Opportunities in Science and Technology, UK (November-December 1990 & July 1991)
- Dr Clem Annice, University of Canberra (November 1990-February 1991)
- Professor Bikkar Randhawa, University of Saskatchewan (February-July 1991)
- Dr Charles Barman, Indiana University (January-May 1991)
- Professor Alan Grifffiths, Memorial University of Newfoundland, Canada (January-June 1991)
- Dr Campbell McRobbie, Queensland University of Technology (February-March 1991)
- Professor Irvin Lehmann, Michigan State University (July-September 1991)
- Professor Denis Phillips, Stanford University (September-November 1991)
- Professor James Shymansky, University of Iowa (January-June 1992)

8. EVALUATION OF THE ACTIVITIES OF THE KEY CENTRE BY A TASKFORCE AND A REVIEW PANEL

In addition to the evaluative feedback obtained from overseas visitors and consultants (see previous section), a taskforce and a review panel have provided very valuable feedback on the work of the Key Centre.

8.1 International Academy of Education Taskforce

During 1989, Professor Barry Fraser was invited to play a major role within a taskforce on science education appointed by the International Academy of Education (IAE) in Brussels. The purpose of this taskforce was to plan an edited book on science education. He received a grant from the IAE to fund a planning meeting of the taskforce at Curtin University during February 1990. As well, Professor Fraser is the senior editor of the book, which is described in Section 4.4

The members of taskforce who attended the meeting in Perth were Professor Herbert Walberg (University of Illinois), Professor George Marx (Roland Eotvos University, Hungary), Professor John Keeves (Flinders University of South Australia) and Dr K C Cheung (Institute of Education, Singapore). The contents of the book, which is entitled 'Improving Science Education', is shown in Appendix D.

During their visit to Western Australia, members of the taskforce spent a day in evaluating the work of the Key Centre and making suggestions about

Key Centre is evaluated by international taskforce including Dr K C Cheung (left), Professor Herbert Walberg (2nd left), Professor George Marx (3rd left) and Dr John Keeves (right) desirable future directions. Having this eminent group of scholars with diverse external perspectives proved to be extremely useful in providing valuable information about the accomplishments of the Key Centre and furnishing numerous ideas for its future operation.

8.2 Panel Appointed to Review SMEC and Key Centre

In October 1990, a distinguished panel appointed by Curtin University reviewed SMEC's postgraduate programs and all aspects of the organisation and operation of SMEC and the Key Centre. The Panel comprised:

- Professor James Gallagher, Michigan State University (Chair)
- Professor Anthony Blake, Deputy Vice-Chancellor, University of Technology, Sydney
- Dr Kaye Stacey, Senior Lecturer, University of Melbourne
- Ms Lesley Parker, then Deputy Director of the Secondary Education Authority of WA
- Mr Brian Davis, Ministry of Education of Western Australia
- Associate Professor Geoff Giddings, Curtin University

Professor James Gallagher (Michigan State University), Chair of Program Review Panel

Some salient extracts from the Review Panel's official report to Curtin University are provided below:

> *SMEC is widely recognised as an international leader in science and mathematics education. It has an extremely high rate of productivity in research and dissemination. When compared with other centres across the University, it is clearly the most productive unit in research and dissemination; and when compared with similar groups within Australia and internationally is clearly among the most productive units.*
>
> *The Director, staff and students work together as a community of scholars. The intellectual climate at SMEC is stimulating and nurturing and it is directed towards the resolution of important practical problems in science and mathematics education utilizing the best examples of research and scholarship.*
>
> *Courses of study are designed to introduce students to the latest ideas in science and mathematics education and in related fields. Courses are conducted in a climate in which students are engaged as co-professionals in attempting to understand and address both current and perennial issues in science and mathematics education.*
>
> *SMEC has the benefit of outstanding leadership, an excellent, dedicated academic staff, a fine secretarial staff, good cooperation with a small group of faculty and administrators from other units, and excellent students from the local area, other parts of Australia, and throughout the Southwest Pacific region.*
>
> *Last, but not least, SMEC should be commended for its establishment and implementation of the national Key Centre for School Science and Mathematics at Curtin University of Technology. This is the only Key Centre in the field of Education. The impact of the Key Centre on Australian science and mathematics education clearly enhances the influence of SMEC and Curtin University of Technology at a national level.*
>
> *One of the strongest pieces of evidence of SMEC's national eminence is to be found in the results of the DEET Discipline Review of Teacher Education in Mathematics and Science. Appendix III indicates that SMEC (in spite of its extremely small staff level) is making a major contribution to research and other professional activities compared to other institutions around Australia. SMEC is, in fact, one of the two leading Australian institutions on both these important dimensions.*
>
> *The Panel considers that the management of SMEC and the associated national Key Centre has been outstanding. The Director of SMEC (and the Key Centre), Professor Barry Fraser, by all standards, must be given a great deal of the credit for the success of both these Centres. His academic, entrepreneurial and leadership skills have enabled him to maximize the efforts of his small SMEC and associated staff, to achieve state, national and international prominence, and to bring great credit to the University as a whole.*

9. INCOME, ESPECIALLY RESEARCH GRANTS

9.1 Sources of Income

The Key Centre/SMEC has seven major sources of income:

- Key Centre annual grant from DEET;
- Recurrent budget from Curtin University for teaching the postgraduate programs for Australian students described in Section 2.2;
- Income from fee-paying overseas students undertaking postgraduate programs (see Section 2.2);
- Consultancies, especially in Indonesia and the Philippines associated with the postgraduate students described in Section 2.2;
- Sales of Key Centre publications (Section 4);
- Enrolments in Key Centre professional development activities, including institutes (Section 5.5) and short courses (Section 2.9);
- Research grants.

Of the above seven sources of income, research grants are considered in further detail in the next section.

9.2 Research Grants

Table 2 provides details of the external research grants that were in progress in mid-1988 at the time when the Key Centre first began, together with all the new external research grants that have been awarded since then. This table shows that Key Centre staff have received $564 000 for 19 different research projects during the period 1988-91.

Commencing in 1990, Curtin University received 'research infrastructure' funds from DEET under its Mechanism B. The Research and Development Committee at Curtin distributes this research infrastructure money based on an index of scholarly productivity involving the size of research grants and the number of publications, conference presentations, etc. SMEC/Key Centre staff submitted a consolidated application and received $109 000 in 1990 and $127 000 in 1991.

Internal Research Infrastructure grants have been recorded at the bottom of Table 2. Overall this table shows that a total of $800 000 has been received in research grants (external grants plus internal research infrastructure allocations) by the Key Centre staff in the period 1988-1991.

10. PUBLICATIONS AND PRESENTATIONS

Appendix E lists the 240 publications of staff of the Key Centre from 1988 onwards. Appendix F provides a list of the 261 conference papers presented by Key Centre staff from 1988 onwards.

11. COOPERATION WITH OTHER INSTITUTIONS AND ORGANISATIONS

Although the major focus during the early years of the Key Centre's existence had to be the establishment of the large range of activities described elsewhere in this report, the Key Centre has been involved in several significant cooperative ventures involving other institutions and organisations. This type of cooperation will become a bigger part of the Key Centre's activities in the future. Cooperative ventures already established are described below.

11.1 Cooperation with Australian Science Teachers' Association on a Special Journal Issue Devoted to Gender Issues

The Key Centre cooperated with the Australian Science Teachers' Association in editing, advertising and distributing a special issue (Volume 15, Number 3, August 1989) of the Association's journal, the *Australian Science Teachers' Journal*, which was devoted to the topic of gender issues in science teaching. The issue was edited by Key Centre staff, Associate Professor David Treagust and Dr Léonie Rennie. The Key Centre has advertised the special issue in some of the publications which were distributed to all schools nationally.

11.2 Cooperation with the Education of Girls in Mathematics and Science Program in Field Testing of Gender-Inclusive Calculus Materials

In 1989, the Department of Employment, Education and Training contracted Ms Mary Barnes of the University of Sydney to conduct an evaluation of gender-inclusive calculus materials which she had prepared as a part of the Education of Girls in Mathematics and Science program. This program was funded initially by the national Curriculum Development Centre. These calculus materials were written with the aim of increasing access of a wider range of students, especially girls, to the major ideas of calculus. The target group is students who intend to go on to tertiary studies, but not necessarily in courses which have mathematics as a major component. The evaluation involves three schools in each of three states, New South Wales, Western Australia and Victoria, and one school from the Australian Capital Territory.

In Western Australia, the Key Centre collaborated with Mary Barnes on this evaluation. A Key Centre staff member, Ms Jayne Johnston, was involved in conducting the evaluation, and the Key Centre provided some clerical support and some help with the dissemination of results (e.g., through the publications which the Key Centre mails to schools). The Western Australian strand of the evaluation involved gathering data through interviews,

TABLE 2. Research Grants

Investigators	Project Title	Source of Funds	Year/s	Total Grant ($ 1 000s)
External Research Grants				
Prof B Fraser	Identifying factors linked with school science achievement through the secondary analysis of a national data base	Australian Research Council (ARC)	1989-90	49
Dr J Malone Mr P Taylor	A pilot project to determine the factors influencing the participation, retention and achievement of Aboriginal students in secondary mathematics	Australian Research Council (ARC)	1989	38
Prof B Fraser Mr P Taylor	Evaluation of the impact of ELIC on the child in the classroom	Ministry of Education, Western Australia	1987-89	25
Prof B Fraser Dr G Giddings	Survey of teachers' opinions about the Unit Curriculum	Ministry of Education of Western Australia	1988-89	7
Dr L Rennie Mrs L Parker Mrs J Offer	Monitoring of Unit Curriculum enrolment patterns	Secondary Education Authority	1988-89	5
Dr D Treagust Dr A Kinnear Dr F Haynes	Development of technology curriculum materials for upper primary school	Technology and Industry Development Authority, WA Government	1987-90	30
Dr D Treagust Dr A Kinnear Dr F Haynes	Upper primary technology project	Curriculum Development Centre, Canberra	1988-90	19
Dr D Treagust Dr L Rennie	Evaluation of the implementation of technology in six WA high schools	Ministry of Education of Western Australia	1989-90	11
Prof B Fraser	Planning and editing a book on science education	International Academy of Education, Brussels	1989-90	13
Dr H Mansfield	Identifying students' misconceptions in geometry & developing teaching strategies to promote conceptual change	Australian Research Council (ARC)	1989-90	28
Prof B Fraser Dr G Giddings	Development, validation and use of an instrument for assessing the psychosocial environment of science laboratory classes	Australian Research Council (ARC)	1990-91	57
Dr D Treagust Mr P Taylor	Student misconceptions in physics and their remediation	Australian International Development Assistance Bureau (AIDAB)	1990	7
Dr J Malone Dr D Miller	A naturalistic study of the meaning of understanding in the context of teaching and learning secondary mathematics	Australian Research Council (ARC) Small Grant	1991	7

continued...

TABLE 2. Research Grants (continued)

Dr L Rennie	Evaluation of teacher and student learning in a 'hands-on' science centre: A pilot study	Australian Research Council (ARC) Small Grant	1991	7
Dr D Treagust	Teachers' use of analogies to enhance students' conceptual understanding in science	Australian Research Council (ARC)	1991-93	99
Prof B Fraser	Hosting a meeting of a taskforce and planning a book on improving science education	International Academy of Education	1990-1991	13
Dr L Rennie Assoc Prof L Parker	Editing and producing a two-volume book based on papers for the sixth international GASAT conference	Science and Technology Awareness Program, Commonwealth Department of Industry, Technology and Commerce	1991	14
Ms D Young Prof B Fraser	Postdoctoral Research Fellowship for a study on factors influencing mathematics and science achievement	Australian Research Council (ARC)	1991-94	130
Assoc Prof L Parker	Curriculum renewal in upper secondary mathematics: A preliminary evaluation	Ministry of Education of Western Australia	1991	5
				564
Internal Research Infrastructure Grants			1990 1991	109 127
Total				800

questionnaires and classroom observations and preparing a report, including case studies of each participating school.

11.3 Cooperation with Australasian Science Education Research Association in Publishing Monographs

The Key Centre cooperated with Associate Professor Jeff Northfield at Monash University and Dr David Symington of Victoria College in publishing an edited *Key Centre Monograph* in the general area of teaching and learning in science (see Section 4.3). In this volume, the editors drew on material presented at previous conferences of the Australasian Science Education Research Association and published in *Research in Science Education*. This publication is entitled 'Learning in Science Viewed as Personal Construction: An Australasian Perspective'.

Currently plans are underway for the Key Centre to cooperate again with the Australasian Science Education Research Association in the production of another monograph, this time dealing with primary science education.

11.4 Cooperation with Other Universities in Offering Teacher Workshops Led by Key Centre Visitors

Section 5.4 has described how the Key Centre has collaborated with other universities in arranging for some of its overseas visitors to offer interstate teacher workshops modelled upon Perth-based professional development institutes. In particular, the Key Centre cooperated with the University of Technology, Sydney in July 1990 to allow Professor Jane Butler Kahle of Miami University in the USA to offer a one-day teachers' workshop based on her institute on gender issues. A similar workshop was presented by Professor Kahle in Brisbane in July 1991 in cooperation with the Centre for Mathematics and Science Education at Queensland University of Technology. Similarly, through collaboration between the Key Centre and the Australian Catholic University in Sydney during September 1990, Professor James Gallagher of Michigan State University offered a teacher workshop based on his institute on teaching for understanding. It is anticipated that another Key Centre visitor, Professor Denis Phillips, will offer a workshop in Sydney in September 1991 in cooperation with University of Technology, Sydney

11.5 Cooperation with Science and Mathematics Teachers' Associations in Providing Key Centre Visitors to Give Keynote Addresses and Run Workshops at Conferences

Section 5.1 describes the way in which the Key Centre has cooperated with teachers' associations. For example, the Key Centre cooperated with the Australian Science Teachers' Association in making Professor Jane Butler Kahle of Miami University, USA, available to make major contributions at the Association's annual conference in Alice Springs in July 1990. Professor Kahle presented a keynote address and a whole-day workshop, both on the topic of gender issues in science teaching. Similarly, Dr Jan Harding from the UK presented a keynote address and a workshop on gender issues at the annual conferences of both the Science Teachers' Association of Victoria and the Mathematical Association of Victoria in Research 1990.

11.6 Cooperation with Science Teachers' Association of Western Australia in Producing a Videotape on Gender Issues

Key Centre staff, especially Dr Léonie Rennie, cooperated with the Science Teachers' Association of Western Australia in producing a videotape entitled *Girls Learning Science: Promoting a Gender-Inclusive Science Curriculum* (see Section 4.5).

11.7 Cooperation with McClintock Collective and State Equal Opportunity Resource Centre in Victoria in Offering a Workshop Involving Jan Harding

In Sections 5.3 and 5.4, some information was provided about the way that the Key Centre made available one of its visiting experts on gender issues (Dr Jan Harding of London) for interaction with teachers in Melbourne around the time of the annual conferences of the Science Teachers' Association of Victoria and the Mathematical Association of Victoria in December 1990. As well as making presentations at these conferences, Dr Harding also acted as a resource person during a teachers' workshop involving the writing of gender-inclusive curriculum materials for the Victorian Certificate of Education. This workshop was made possible through collaborative arrangements between the Key Centre, the McClintock Collective (a national network of teachers which promotes gender-inclusive teaching in science) in Melbourne and the State Equal Opportunity Resource Centre in Geelong.

11.8 Cooperation with Mathematics Education Research Group of Australasia in Establishing a Practical Applications Award

To coincide with the staging during July 1991 of the joint conference of the Mathematics Education Research Group of Australasia (MERGA) and the Mathematics Education Lecturers' Association (MELA) in Perth, the Key Centre announced its sponsorship of a new *Practical Implications Award*. This award, which will consist of a plaque bearing the name(s) of the winner(s) and a cash prize of $500, will be awarded to the author(s) of the research paper presented at MERGA's annual conference considered to contain findings with the best practical implications for improving mathematics teaching. Presenters are given to the end of each year to submit papers which will be judged by a panel of two members from MERGA and two from the Key Centre. The winner will be announced at the following conference of MERGA and the paper will be presented in a special time slot at that meeting. Also there will be an opportunity for prize-winning papers to be modified for publication in the Key Centre's *What Research Says to the Science and Mathematics Teacher* series (see Section 4.2).

12. FUTURE PLANS

The ambitious plans for the future build upon the accomplishments to date and already have been described in various places throughout this report.

Postgraduate Programs

Various steps will be taken to continue to publicise, enhance the quality of and increase enrolments in the postgraduate programs offered to practising science and mathematics teachers for either internal or external study (see Section 2). In particular, these plans include continuing to enlarge the suite of units available for external study. Another way in which the postgraduate program will be made more accessible Australia-wide will be to offer more units that can be studied in the external mode during the summer holidays and to continue to offer professional development institutes in the school holidays. Again, the expertise of overseas visiting scholars will be available for teaching units within the postgraduate programs. Various measures aimed at making these courses better known and more accessible to all science and mathematics teachers throughout Australia will be implemented throughout 1991.

The most significant pioneering contribution which the Key Centre will make to the professional development of teachers during 1992 is that it will have its first intake into Australia's first 'professional' doctoral degree by coursework and thesis specifically in science, and mathematics and technology education. The new degree is called the Doctor of Science Education (ScEdD).

Access to doctoral studies in science and mathematics education will be enhanced in 1992 when the Key Centre will begin to offer 'top up' scholarships to full-time students and travel scholarships to part-time students (Section 2.12).

Research

The year ahead will be an important time for completing current studies and initiating new research. Areas of research will continue to encompass gender issues, learning and teaching, enrolment patterns, classroom environment, Aboriginal students, constructivist styles of teaching and learning and factors linked with student achievement (see Section 3). External funding to support some of these projects in 1992 has been requested from the Australian Research Council and other sources. Postgraduate students' research again will continue to contribute enormously to the Key Centre's research effort.

Publications

The publication program already established will continue (Section 4). Numerous issues will be added to the very successful *News-sheet* and *What Research Says to the Science and Mathematics Teacher* series, and more *Key Centre Monographs* will be published. As well, work will continue on various edited books in preparation, including ones on gender issues and on learning and teaching of science and mathematics (see Section 4.4). Videotapes as well as written materials will continue to be produced (see Section 4.5). The distribution of materials to Australia's 2 500 secondary schools again will be a major vehicle for massive national dissemination for the remainder of 1991 and during 1992.

Contact with Teachers

Face-to-face contact between Key Centre staff and teachers again will be a priority area in the future. Key Centre staff will make numerous presentations at various national and state conferences of science and mathematics teachers' associations and display an exhibit in the exhibitors' area (Sections 5.1 and 5.2). Professional development institutes at Curtin University (Section 5.5) again will be a major vehicle by which some teachers will receive comprehensive, face-to-face, in-depth professional development opportunities during school holidays. A noteworthy feature of these institutes is the way that they can be taken as credit towards Curtin's postgraduate programs in science and mathematics education if students complete assignments in the external studies mode after attending the institutes. The national impact of the Key Centre's program of professional development institutes again will be enhanced by having institute leaders present abbreviated versions of institutes at one or more interstate locations (Section 6).

Miscellaneous

As well, the work of the Key Centre will be enhanced greatly in the year ahead through visits from numerous eminent overseas visitors (Section 7). The Key Centre's popular seminar series will continue to contribute to the professional development of internal students and local teachers who attend the sessions, and also will be accessible to external students through videotapes or audiotapes (Section 6).

Cooperation with other institutions and organisations during 1991 will be an important way of multiplying the Key Centre's impact and enlisting assistance in furthering the Key Centre's goals (see Section 11).

The Key Centre will be sponsoring the first Australian stop for a British exhibit entitled *Common Threads*. This exhibition was originally designed and produced by Mary Harris of the Maths in Work Project at the Department of Mathematics, Statistics and Computing of the University of London Institute of Education. The Maths in Work Project aims to make closer links between school mathematics and the mathematics that goes on outside school. It involves analysing the mathematics implicit in everyday and working activities and developing learning materials from the results of the analysis. In response to requests from the international educational community, the Education Department of the British Council decided to take up and organize a tour of the exhibition to help promote the idea of using everyday activities as a resource for realistic and relevant school mathematics. The *Common Threads* exhibition, therefore, was redesigned by the British Council to fulfil these functions. The exhibit will arrive in Perth in October 1991 and be on display at Curtin University under the direction and sponsorship of the Key Centre.

In order to ensure maximum possible benefit from the exhibition, staff of the Key Centre are organizing seminars for teachers and trainee teachers, and collaborating with the Mathematics Teachers' Association of WA and the Ministry of Education of

WA to provide a range of professional development opportunities for teachers.

The Key Centre was very successful in 1989 and 1990 in setting up mechanisms for reaching vast numbers of people comprising its major primary audience — science and mathematics teachers in Australia's 2 500 secondary schools. Towards the end of 1991 and during 1992, the Key Centre will increase its involvement, contact and cooperation with its main secondary audiences, namely, the science and mathematics teacher educators in universities and colleges and science and mathematics consultants, advisors and curriculum developers in state systems of education. For example, currently the Key Centre is compiling complex mailing lists which will enable it to mail to its secondary audiences the same published materials (e.g., *Newssheet, What Research Says* issues) which previously have been sent to science and mathematics teachers throughout Australia.

13. REFERENCES

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Taylor, P.C., & Fraser, B.J. (1991, April). *Development of an instrument for assessing constructivist learning environments*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

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APPENDIX A

Details of PhD Students in August 1991

Name	Thesis Title	Current Position	Place of Residence
Cronin, Patrick	An investigation of the factors determining the science literacy of high school students	Private school Principal	South Australia
Eastwell Peter	The effects of extracurricula science activities on students' further participation in science	Teacher, The Scots PGC College	Queensland
Ferguson, Peter	Nature and effects of changes in science students' attitudes and the classroom environment during the transition from primary to secondary school.	Lecturer, University of Tasmania	Tasmania
Hand, Brian	The implementation of approaches to teaching and learning using a constructivist strategy among a whole school science department	Lecturer, La Trobe University (Bendigo campus)	Victoria
Havel, Peter	A science department's contribution to a whole school approach to developing writing competence	Deputy Principal, Ministry of Education of WA	Perth
Henderson, Trevor	Student learning in interactive science centres	Education Officer, Scitech Discovery Centre	Perth
Idiris, Suleiman	A study of school learning environment for agricultural science in Nigerian schools	Full-time overseas student	Nigeria
Lewis, Cherie	Transmission and acquisition of knowledge about bonding and structure concepts in chemistry	Private school science teacher, Ministry of Education of WA	Perth
Maor, Dorit	Inquiry skills and classroom environment associated with use of computer database module in secondary school biology	Full-time student on scholarship	Perth
Oliver, Ronald[a]	The efficacy of an alternative model for teaching introductory computer programming	Lecturer, Edith Cowan University	Perth
Palmer, William	A study of the teaching and learning of two of the bulk properties of substances, frequently known as physical and chemical change	Senior Lecturer, Northern Territory University	Northern Territory
Parker, Lesley	The gender code of school science : A study of the relationship between gender and science	Associate Professor, Curtin University	Perth
Perso, Thelma	Misconceptions in algebra: Their identification and treatment	Full-time student on scholarship	Perth
Peterson, Raymond	The development of pre-service primary teachers' knowledge bases in science and science education through the implementation of a problem-based learning program	Lecturer, La Trobe University (Bendigo campus)	Victoria
Russo, Sharon	Models of science and technology instructional programs for pre-school children	Lecturer, University of South Australia	South Australia

Smith, Thomas	The effect of modifications to the style of written agricultural scientific and extension communications on adult readers' comprehension	Adviser, Agriculture Protection Board	Perth
Stocklmayer, Sue	Images of electricity: A comparison of experts' and novices' mental models of electrical circuits, with implications for classroom practice.	Full-time student on scholarship	Perth
Tan Angela	A study of the knowledge, beliefs and classroom practices of expert primary science teachers in Singapore	Lecturer, Nanyang Technological University, Singapore	Singapore
Taylor, Peter	A study of the development of constructivist teaching styles among secondary school teachers of mathematics	Lecturer, Curtin University	Perth
Thiele, Rodney	Teachers' and students' use of analogies for improving conceptual understanding and enhancing conceptual change in secondary chemistry education	Full-time student on scholarship	Perth
Waldrip, Bruce	A study of achievement, attitudes, teaching practices and learning environment in secondary school science laboratory classes in Papua New Guinea	Lecturer, Pacific Adventist College, PNG	Papua New Guinea
White, Loren	A study of students' decision making: Personal values versus subject values in school mathematics	Teacher, Ministry of Education of WA	Perth
White, Robyn	A study of the beliefs and practices of the heroes of science education in Western Australia	Deputy Principal, Ministry of Education of WA	Perth
Young, Deidra[a]	Gender differences in science achievement: Secondary analysis of data from the Second International Science Study	Research Officer, Women's Cancer Prevention Unit	Perth

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[a] These students recently completed all requirements for the award of the PhD.

APPENDIX B

Master's Theses and Projects Completed in 1989, Completed in 1990 and Currently in Progress

Theses Completed in 1989

The development and evaluation of a video-taped lesson designed to improve learning of genetics by upper secondary distance education students (I Edwards)

A microcomputer software package to facilitate concept analysis in curriculum development (A Inglis)

A comparison of the effectiveness of computer assisted and computer managed instruction for different sub-populations of a secondary school (G St John)

Teacher perceptions of issues related to the Web of Life biology course and how they affect the intended curriculum (I Sydney-Smith)

The effective science teacher: The perceptions of principals and science teachers in Victoria (B Waldrip)

Theses Completed in 1990

The impact on teaching methodology of the 1987 Western Australian lower secondary mathematics syllabus (D Haimes)

The acquisition of physics knowledge and factors influencing achievement of mature age students in the Year 12 TEE physics course (T Henderson)

Teacher cognitive processes: Strategies used by experienced teachers to transform subject matter content knowledge into pedagogical content knowledge (P Lewis)

The design and evaluation of a learning package for the teaching of place value and decimals to the less able student (T Perso)

The application of latent trait psychometric theory to the analysis of item difficulty and sex bias in the Western Australian TEE Mathematics III examination (C Smith)

An evaluation of the factors contributing to the implementation of a process-oriented science curriculum (S Stocklmayer)

Theses Currently in Progress

Priorities for the inclusion of societal and technological issues in the science curriculum: Opinions of experienced classroom teachers in Western Australia (M Alexander)

The influence of a field study program in Year 11 Biology on students' knowledge of and attitudes towards the environment (T Allan)

A study of primary school teacher inservice needs for environmental education in South Australia (J Bishop)

Competencies required by occupational health nurses: A needs assessment of registered nurses practising in the occupational health field (B Booker)

Development of visuo-spatial abilities among undergraduate earth science students (J Broadfoot)

A conceptual change approach to student comprehension of selected concepts about liquids (G Bunn)

Pre-registration nursing students and science: Perceptions of difficulty and results of achievement (M Caon)

An evaluation of an employee heart health and lifestyle programme in Darwin, Northern Territory (S Carr)

Evaluation of inservice materials for fire officers at CALM (T Carboon)

An investigation of the use and understanding of the language of physical time by pre-primary children (F Ciupryk)

Factors influencing the participation, achievement and retention of Aboriginal students of mathematics (B Densley)

An evaluation of a lower school content area reading comprehension improvement strategy (F. Dröge)

Evaluation of a school-based secondary science programme in an Aboriginal community school (S Garrett)

Upper school mathematics and career destination: A case study (B Hamlett)

Teacher-perceived tensions towards different assessment and credentialling requirements of two categories of Year 12 science subjects (E Jacob)

An examination of the interrelation between study habits and student personality types among Year 11 biology students (T Jess)

The influence of typographic variables on the learning process: The presentation of instructional texts for distance education (N Kemp)

Pedagogical knowledge base and teacher planning (G Lake)

A study of the effectiveness of a model for conducting mathematical investigations with lower achieving Year 8 students (L McClellan)

The role of metacognitive processes among upper primary students of mathematics during problem-solving experiences (J Neale)

Aboriginal perspectives in the NSW science curriculum (W Needham)

Staff perceptions of the work environment at a new high school in South East Queensland (D Potter)

Teacher perceptions of the effect of core curriculum on teaching of science in the NT (R Ralph)

The acquisition of library skills in science by low achieving Year 8 secondary students and their attitude to science and reading comprehension (P Reid)

Factors influencing the attitude of first-year pre-service primary school teachers towards computers (D Roberts)

The development and evaluation of an inservice programme to increase teacher uptake of micro-computer applications in the science laboratory (D Russell)

Soldiers' retention of the numeracy skills acquired through attendance at Army Education courses (W Sercombe)

A study of the factors influencing students' choice of a mathematics unit at the Year 12 level in Western Australia (G Spyker)

Changing pre-service primary school teachers' attitudes to the teaching and learning of mathematics using a constructivist approach (S Tobias)

The effect of the Western Australian Mathematics Course (JIM) on the development of spatial abilities and problem solving skills among Year 8 students (J Tsakalos)

Projects Completed in 1989

The effect of PKG teacher training on the attitudes of secondary school teachers in West Kalimantan towards the teaching of science and mathematics (P H Abik)

An ethnographic study of the questioning skills of an exemplary teacher of grade 3 science in a SMP in Jakarta (A Adjis)

A qualitative study of student motivation in a Grade 8 middle school science class (G Casey)

An investigation of practical skills performance in physics of Grade 3 SMP students in Ambon, Indonesia (A J Esomar)

Secondary science teachers' epistemologies and their influence on secondary science pedagogy (J Hockenhull)

An investigation into the needs and difficulties experienced by physics teachers in PKG compared to SPKG (B Irianto)

An investigation into student and teacher activities in biology classes taught by PKG teachers in Bali (P Jelantik)

An investigation of the attitudes of senior secondary schools science teachers to the implementation of the PKG-IPA's model of teaching in Kupang, Indonesia (C Kartikawati)

The development and trialling of a diagnostic instrument to measure student knowledge and understanding of electromagnetism concepts (G McPaulus)

A study of primary school children's views about natural phenomena (S Pauka)

Future directions for mathematics education (D Pinto)

A summative evaluation of the PKG principals inservice course: The impact on secondary science teachers in West Kalimantan (Safari)

The development of student worksheets in the topic of set theory based on a process skills approach for first grade students in Kupang City (F Shadiq)

Student performance in undergraduate management science courses and their relationships to gender and attitude (S Sim)

Thai secondary students opinions and attitudes towards practical work in physics (C Sirichote)

The development of an instrument to collect information about many aspects of teaching the topic 'computer studies' to first year classes SMA in the city of Surabaya, Indonesia (G Sumilih)

A comparison of achievement and classroom environment of students taught by key and regular teachers (T Supeni)

The relationship between students' attitudes and achievement in chemistry at senior school in Manado, Indonesia (R J Wongkar)

Projects Completed in 1990

An analysis of laboratory safety standards, real and legislated, in Western Australian high schools (P Forlin)

Untitled (completed at Florida State University) (L White)

Children making sense of school and science (completed at Florida State University) (R White)

Projects Currently in Progress

A study of effect of practical skill in biology on student's achievements in the secondary junior school of Mataram, Lombok, Indonesia (I Ketut Sutanaya Adnyana)

A study of students' mathematical ability and attitude towards physics as correlates of achievement in physics in Year 2 SMA Jambi (Asmadi)

The relationship between students' attitude to and achievement in chemistry at the school level in Bandung, West Java, Indonesia (Zulbahri Bahar)

An investigation of the impact of the PKG Matematik Program in secondary schools in Ambon, Indonesia (Dominggus Latuihamallo)

Evaluation instruments for science teaching centres and science museums: Uses and application for measurement of science knowledge and attitude (T McClafferty)

An evaluation of the WA Mines Department Seminar Series for teachers (A McLaren)

Students' understanding of vectors in junior and secondary schools, Banda Aceh, Indonesia (Anwar Muhammad)

The effect of group practical tasks on students' understanding of photosynthesis (Mukasiba Paturungi)

An investigation of the relationship between student achievement in physics and science process skills in senior secondary schools in Samarinda (Supriyono)

APPENDIX C

Seminar Series Sponsored by SMEC and the Key Centre

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SEMINAR SERIES

Semester 1, 1989

Date	Speaker	Topic
February 23	Dr Olu Jegede Head of Science Education Ahmadu Bello University, Nigeria	Eco-cultural influences on the science concept attainment of students in an African society
March 2	Dr David Treagust & Mr Peter Taylor, SMEC Curtin University of Technology	An Australian perspective on inservice for science and mathematics teachers in Indonesia
March 9	Dr Ference Marton Professor of Education University of Goteborg, Sweden	The perceptibility of numbers and the origin of arithmetic skills
March 16	Dr Menahem Finegold Associate Professor Technion Institute of Technology, Israel	The Second International Science Study (SISS): The Canadian experience
April 27	Mr Jerry Mortensen Visiting Fellow Murdoch University	Mortensen more than maths
May 4	Dr Howard Birnie Professor of Education University of Saskatchewan, Canada	Teaching for more than content objectives in secondary school physics
May 11	Dr Diane Miller Assistant Professor of Education Louisiana State University	Generalists become specialists in the teaching of elementary mathematics and science
May 25	Mr David Haimes Senior Master of Mathematics Duncraig Senior High School, Perth	Secondary mathematics teaching in Canada: Parallels and contrasts with Western Australia
June 1	Ms Pam Garnett Science Teacher St Hilda's Anglican School for Girls, Perth	Students' misconceptions in Electrochemistry
June 8	Dr Svein Sjøberg, Director Centre for Science Education University of Oslo, Norway	Piaget, 'constructivism' and science-education: Some examples from Norwegian research

Venue: Boardroom (Room 118), Applied Sciences Building (Building 311)
Curtin University of Technology (Use Car Park Number 1, off Hayman Road.)

Time: 5:00 to 6:15 pm

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APPENDIX C (continued)

Seminar Series Sponsored by SMEC and the Key Centre

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SEMINAR SERIES

Semester 2, 1989

Date	Speaker	Topic
August 3	Rosemary Fraser Shell Centre for Mathematics Education University of Nottingham	Use of computers in complex human situations
August 10	Professor Hugh Burkhardt Director, Shell Centre for Mathematics Education University of Nottingham	Technology and autonomy: The revolutions in mathematics and mathematical education
August 17	Dr Dale Spender Fellow of the University of London	Mathematics and science education: Is there a right answer to questions of equity?
August 24	Dr Peter Sekhon School of Mathematical Sciences University of Technology, Sydney	PhD mathematics education: Implications for Australia's industrial future
August 31	Dr Avi Hofstein Weizmann Institute, Israel	Motivating students to more effective science learning
September 14	Professor Barry Fraser and Assoc. Professor John Malone Curtin University of Technology	The Key Centre for Teaching and Research in School Science and Mathematics (especially for women): A proactive endeavour
September 28	Professor John de Laeter and Assoc. Professor John Malone Curtin University of Technology	Enrolment trends in upper secondary school science and mathematics in Australia
October 19	Dr David Treagust Science and Mathematics Education Centre Curtin University of Technology	Using classroom research to enhance the teaching of physics
October 26	Professor Rod Doran Faculty of Educational Studies State University of New York	Assessment of student performance in science laboratories
November 2	Dr Linda DeTure School of Education Rollins College, Florida	Using wait-time in the classroom

Venue: Seminar Room (Rm 222), Geology Building (Bld 312)
Curtin University of Technology (Use Car Park No. 1, off Hayman Road)

Time: 5:00 to 6:15 pm

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APPENDIX C (continued)

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SEMINAR SERIES

Semester 1, 1990

Date	Speaker	Topic
March 1	Dr Peter Lewis Head of Science Christ Church Grammar School	Images of chemical education: Some international perspectives
March 8	Professor Walter Smith Department of Curriculum and Instruction University of Kansas	COMETS: Career Oriented Modules to Explore Topics in Science
March 15	Dr Theo Wubbels Associate Chair Centre for Science and Mathematics Education University of Utrecht, The Netherlands	Student perceptions of interpersonal teacher behaviours
March 22	Dr Louise Gann Science Supervisor and Head of Department Alcoa City System, Tennessee	Writing across the curriculum emphasising science and mathematics
April 5	Sir Wilfred Cockcroft Chairman, Secondary Examinations Council United Kingdom	Mathematics in a National Curriculum
May 17	Dr John Wallace Consultant, Curriculum Policy Ministry of Education	Imagination: The phantom of the classroom
May 24	Mr Barry Kissane and Ms Marion Kemp Lecturers in Mathematics Education Murdoch University	Numeracy: What is it and why do we need it?
May 31	Mr Peter Taylor Lecturer, SMEC Curtin University of Technology	Constructivism in the classroom
June 7	Professor Barry Fraser, Dr Geoff Giddings and Mr Peter Titmanus Curtin University of Technology	Survey of teachers' opinions about the unit curriculum
June 14	Dr Tom Kandl Assistant Professor of Mathematics Education Slippery Rock University, Pennsylvania	Student-teacher interactions in teaching/learning mathematics

Venue: Geology Seminar Room (Rm 222), Geology Building (Bld 312)
Curtin University of Technology (Use Car Park No. 1, off Hayman Road)

Time: 5:00 to 6:15 pm

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APPENDIX C (continued)

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SEMINAR SERIES

Semester 2, 1990

Date	Speaker	Topic
August 2	Dr Jane Butler Kahle Condit Professor of Science Education Miami University, Ohio	A theoretical explanation for the under-representation of girls and women in science, mathematics and technology
August 9	Dr Joseph Menis Bar Ilan University Israel	The Second International Science Study: A cross-national perspective
August 16	Ian Sydney-Smith Curriculum and Moderation Officer (Science) Secondary Education Authority	Evaluation of the *Web of Life* biology course using teachers' perceptions
September 6	Janifer Darbyshire President Accelerative Learning Society	Learning made easy
September 13	Tony Fetherstonhaugh Science Teacher Presbyterian Ladies College	Misconceptions and light: A curriculum approach
October 11	Dr Tom Kandl and Dr Diane Miller SMEC Curtin University of Technology	Teaching for understanding in secondary mathematics
October 18	Dr Jim Gallagher Institute for Research on Teaching Michigan State University	The practices, knowledge and beliefs of secondary science teachers: A basis for restructuring
October 25	Dr Harry Edgar and Dr Ian Docherty School of Electrical and Computer Engineering, Curtin University of Technology	The development of Surrogate Laboratory Multimedia as a means of improving the quality and delivery of technical education
November 1	Tony Noonan and Dr David Treagust Ministry of Education and SMEC	Technology education and employer partnerships
November 15	Schulamith Eckstein Technion, Israel	Stages in conceptual development

Venue: Geology Seminar Room (Rm 222), Geology Building (Bld 312)
Curtin University of Technology (Use Car Park No. 1, off Hayman Road)

Time: 5:00 to 6:15 pm

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SEMINAR SERIES

Semester 1, 1991

Date	Speaker	Topic
28 February	Mr David Haimes Head of Mathematics Duncraig Senior High School	Impact of the new secondary mathematics school syllabus on teaching in Western Australia
7 March	Professor Alan Griffiths Memorial University of Newfoundland	Secondary school students' views of the nature of science
14 March	Professor Randy Randhawa University of Saskatchewan	Gender differences in academic achievement: A close look at mathematics
21 March	Dr Peter Okebukola Lagos State University	Can good concept mappers be good problem solvers in science?
28 March	Dr Charles Barman Indiana University Indianapolis, Indiana	Learning about thinking and thinking about learning
2 May	Ms Alison Lee Educational Services & Teaching Research Unit, Murdoch University	Gender differences in writing in science: A socially critical perspective
9 May	Associate Professor Lesley Parker SMEC Curtin University of Technology	Gender issues in science and mathematics education: A unit for use in the professional development of teachers
16 May	Ms Deidra Young Senior Research Officer Women's Cancer Prevention Unit Health Department of WA	Socio-educational factors influencing science achievement: A multilevel analysis
30 May	Ms Jayne Johnston Mathematics Consultant Ministry of Education, WA	Humanizing the study of calculus

For further information, please contact SMEC on 351-7896

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APPENDIX C (continued)

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SEMINAR SERIES

Semester 2, 1991

Date	Speaker	Topic
1 August	Dr David Treagust Dr Léonie Rennie SMEC	An evaluation of technology education in six W.A. secondary schools
8 August	Dr Jan Harding Consultant for Equal Opportunities in Science & Technology, United Kingdom	Implications of a gender-inclusive curriculum
15 August (Boardroom)	Dr Kate Scantlebury Curriculum & Instruction University of Maine (USA)	Assessing the equitable science classroom
22 August (Boardroom)	Prof Irv Lehmann College of Education Michigan State University (USA)	Contemporary issues in assessment and evaluation
29 August (Boardroom)	Mr Ron Oliver Edith Cowan University	Teaching computing in schools
12 September	Dr Sue Willis School of Education Murdoch University	Prime Minister's Science Council
19 September	Drs Diane Miller & John Malone SMEC Mr Will Karmelita Professional Education Consultants	Secondary students' understanding of mathematics vocabulary
26 September	Dr Gilah Leder Faculty of Education Monash University	A practical approach to mathematics in the workplace
17 October	Prof Denis Phillips School of Education Stanford University (USA)	Philosophy of mathematics/science
24 October	Ms Mary Harris United Kingdom	*Common Threads*

Venue is the Geology Seminar Room except 15, 22, and 29 August. These seminars will be held in the SMEC Boardroom.

For further information, please contact SMEC on 351-7896.

APPENDIX D

Contents of Eight Books

Exemplary Practice in Science and Mathematics Education
Edited by Kenneth Tobin and Barry J. Fraser
(Published by Key Centre as a Second Edition in 1989)

1. *Introduction to the Exemplary Practice in Science and Mathematics Education Study* (Kenneth Tobin and Barry Fraser, Curtin University)
2. *A Comparison of Exemplary and Non-Exemplary Teachers of Science and Mathematics* (Kenneth Tobin)
3. *Exemplary Practice in High School Biology Classes* (David Treagust , Curtin University)
4. *Teaching for Understanding: Exemplary Practice in High School Chemistry* (Patrick Garnett, Western Australian College of Advanced Education)
5. *Forces which Shape the Practices of Exemplary High School Physics Teacher* (John Deacon, Curtin University)
6. *'Good' Teaching of Invalid Information: Exemplary Junior Secondary Science Teachers Outside their Field of Expertise* (John Happs, Western Australian College of Advanced Education)
7. *Exemplary Teaching in Upper Primary Science Classes* (Dennis Goodrum, Western Australian College of Advanced Education)
8. *Exemplary Primary Science Teaching* (Trevor Lacy, Ministry of Education of W.A).
9. *Exemplary Teaching Practice in High School Mathematics* (Peter Taylor, Curtin University)
10. *Forces Affecting the Implemented Curriculum in Mathematics Classes of Exemplary Primary Teachers* (Richard Korbosky, Western Australian College of Advanced Education)
11. *Exemplary Teaching in Materials-Centred Primary Mathematics Classes* (Jillian Neale, Ministry of Education of W.A. and John Malone, Curtin University)
12. *Exemplary Mathematics Teaching at the Year 1 Level* (Frances Ciupryk, Western Australian College of Advanced Education and John Malone, Curtin University)
13. *Psychosocial Environment in Classrooms of Exemplary Teachers* (Barry Fraser, Curtin University)
14. *Results and Discussion* (Kenneth Tobin and Barry Fraser, Curtin University)

The Mathematics Curriculum: Towards the Year 2000
Edited by John Malone, Hugh Burkhardt and Christine Kietel
(Proceedings of the Sixth International Congress on Mathematical Education, Budapest, 1988)
(Published by Curtin University in 1989)

Introduction
Two Surveys
The Mathematics Curriculum in the Year 2000
    Introduction
    Curriculum
    Exemplars
    Surveys
    National viewpoints

The Impact of Computer Technology on the Mathematics Curriculum
    Introduction
    Curriculum and exemplars
    Surveys
The Teacher as a Critical Agent in Curriculum Change and Implementation
The Dynamics of Planned Curriculum Change
    Introduction
    Review
    Papers
    A survey

Windows into Science Classrooms: Problems Associated with Higher-level Cognitive Learning

Edited by Kenneth Tobin, Jane Butler Kahle and Barry J. Fraser
(London, Falmer Press, 1990)

1. *Learning Science with Understanding: In Search of the Holy Grail?* (Kenneth Tobin, Florida State University, Jane Butler Kahle, Miami University, Ohio and Barry Fraser, Curtin University)

2. *Methods and Background* (Kenneth Tobin)

3. *Teacher Mind Frames and Science Learning* (Kenneth Tobin)

4. *Real Students Take Chemistry and Physics: Gender Issues* (Jane Butler Kahle)

5. *The Cognitive Level of Curriculum and Instruction: Teaching the Four Rs* (Floyd Nordland, Purdue University)

6. *Student Participation and Motivational Orientations: What Students Do in Science* (Léonie Rennie, Curtin University)

7. *Students' Perceptions of their Classroom Environment* (Barry Fraser)

8. *Conclusion: Barriers to Higher-Level Cognitive Learning in Science* (Kenneth Tobin, Jane Butler Kahle and Barry Fraser)

Educational Environments: Evaluation, Antecedents and Consequences

Edited by Barry J. Fraser and Herbert J. Walberg
(Oxford, Pergamon Press, 1991)

Part A: Overviews of Research Programs

1. *Two Decades of Classroom Environment Research* (Barry Fraser, Curtin University)

2. *Connections Between School, Work, and Family Settings* (Rudolf Moos, Stanford University)

3. *Cooperative Learning and Classroom and School Climate* (David Johnson and Roger Johnson, University of Minnesota)

4. *Families, Schools, and Students' Educational Outcomes* (Kevin Marjoribanks, University of Adelaide)

5. *Educational Productivity and Talent Development* (Herbert Walberg, University of Illinois)

Part B: Specific Research Studies

6. *Classroom Environment and the Transition to Junior High School* (Carol Midgley, Jacquelynne Eccles and Harriet Feldlaufer, University of Michigan)

7. *Interpersonal Teacher Behavior in the Classroom* (Theo Wubbels, Mieke Brekelmans and Herman Hooymayers, University of Utrecht, The Netherlands)

8. *Organizational Climate in Child Care Settings* (Paula Jorde-Bloom, National-Louis University, USA)
9. *Communicative Behaviors in Two Kindergarten Classrooms* (Sue Roark Calnek and Zelda Chevalier, State University of New York)
10. *Teachers' Personal Epistemologies and Classroom Learning Environments* (Elizabeth Jakubowski and Kenneth Tobin, Florida State University)
11. *Study Processes in Grade 12 Environments* (Paul Ramdsden, University of Melbourne)
12. *Structural Links between Achievement and Contextual Measures* (Bikkar Randhawa, University of Saskatchewan)
13. *Learning Environments and Teacher Attitudes in French-Speaking Canada* (Vidya Bhushan, Laval University, Quebec)
14. *Influencing the Learning Environments of Student Teaching* (Richard Duschl, University of Pittsburg and Hersholt Waxman, University of Houston)
15. *Combining Qualitative and Quantitative Methods in Classroom Environment Research* (Barry Fraser, Curtin University and Kenneth Tobin, Florida State University)

Gender, Science and Mathematics: Shortening the Shadow
Edited by Lesley H. Parker, Léonie J. Rennie and Barry J. Fraser
(Currently in Preparation)

Section I: Confronting Perceptions and Attitudes

1. *The Multiple Realities of Science and Mathematics* (Sue Willis, Murdoch University)
2. *Science in a Masculine Straight Jacket* (Jan Harding, Equal Opportunities, Science and Technology, Hampshire, UK)
3. *Student Teachers' Conceptions of Science and Science Teaching* (Sharon Haggerty, University of Western Ontario)
4. *Perceptions of the Relationship between Gender, Science and Mathematics* (Lesley Parker, Léonie Rennie and others, Curtin University)
5. *Revealing Assumptions: Gender Issues in School Mathematics and Science* (Mairead Dunne, University of Birmingham and Jayne Johnston, Ministry of Education of W.A.)

Section II: The Reality of School, Classroom, Curriculum and Assessment

6. *Patterns of Science and Mathematics Achievement: Implications for Assessment* (John Keeves, Flinders University and Dieter Kotte, University of Hamburg)
7. *The Gender Structures of School Communities* (Terry Evans, Deakin University)
8. *Equity in the Mathematics Classroom: Beyond the Rhetoric* (Gilah Leder, Monash University)
9. *Differential Engagement of Males and Females in Science* (Kenneth Tobin, Florida State University)
10. *Gender Equity in Science Curricula and Textbooks* (Ilja Mottier, Ministry of Education and Science, The Netherlands)
11. *Gender and Assessment Practice in Science* (Patricia Murphy, Open University)

Section III: From Policy to Practice: Criteria for Success

12. *Equitable Science Education: A Discrepancy Model* (Jane Butler Kahle, Miami University, Ohio)

13. *The Role of Credible Communicators in Implementing Gender-Equity Initiatives* (Thomas Koballa, University of Texas at Austin)

14. *Action Research and the Implementation of Change* (Doris Jorde and Anne Lea, University of Oslo)

15. *SOS – Skills and Opportunities in Science* (Beverly Farmer, Lorraine McCowan and Elizabeth Godfrey, University of Auckland)

Section IV: From Policy to Practice: Cross-cultural Comparison

16. *Maths/Science Equity: A View from Two Perspectives* (Nancy Kreinberg and Sue Lewis, University of California, Berkeley)

17. *Gender Equitable Science Teaching: A Persuasive Communication Approach* (Léonie Rennie and Lesley Parker, Curtin University)

Teaching and Learning in Science and Mathematics

Edited by David F. Treagust, Reinders Duit and Barry J. Fraser

(Currently in Preparation)

Part I: Investigating Student Understanding of Science and Mathematics

1. *Investigating Student Understanding as a Prerequisite to Improving Teaching and Learning of Science and Mathematics* (Reinders Duit, University of Kiel, Germany, David Treagust and Helen Mansfield, Curtin University)

2. *Concept Mapping* (Joseph Novak, Cornell University, USA)

3. *Multiple Choice Items* (David Treagust)

4. *Interviews about Instances and Interviews about Phenomena* (Malcolm Carr, University of Waikato, New Zealand)

5. *Using Interviews to Probe Understanding of Multiplication Tasks* (Les Steffe, University of Georgia)

6. *Word Association Tests* (Reinders Duit)

7. *Difficulties in Interpreting Interview Data* (Walter Jung, University of Frankfurt, Germany)

8. *Using Computers for Feedback about Knowledge Learned* (Fred Goldberg, San Diego State University)

Part II: Improving Curriculum and Teaching in Science and Mathematics

9. *Reorganizing the Curriculum and Teaching to Improve Learning of Science and Mathematics* (Reinders Duit and Jere Confrey, Cornell University, USA)

10. *Strategies for Remediating Learning Difficulties in Chemistry* (Ruth Ben-Zvi and Avi Hofstein, Weizmann Institute, Israel)

11. *Improving Mathematics Teaching and Learning by Interactive Construction of Meaning* (H. Bauersfeld and J. Voigt, University of Bielefeld, Germany)

12. *Problem Solving Using SEMNET: An Approach to Concept Mapping by Computers* (Kathleen Fisher, San Diego State University and Michael Jay, University of California, Berkeley)

13. *A Constructivist Approach to Implementing Curriculum Change and Teaching* (Rosalind Driver, University of Leeds)

14. *A Conceptual Change Approach to Improving Student Learning* (Peter Hewson, University of Wisconsin)

15. *Changing the Curriculum to Help Students Improve Their Understanding of Functions* (Jere Confrey)

16. *Using Conceptual Change and Reasoning Problems in Introductory Electricity Education* (Peter Licht, Free University, Amsterdam)

17. *Improving Student Conceptions of Parallel Lines* (Helen Mansfield)

Part III: Implementing Teacher Change in Science and Mathematics

18. *Teacher Change as a Means of Improving the Learning and Teaching of Science and Mathematics* (Kenneth Tobin, Florida State University)

19. *Meta-cognitive Strategies for Use in the Classroom* (John Baird and Richard White, Monash University)

20. *Teacher Empowerment* (Mariona Espinet, Spain)

21. *Implementing Teacher Change at the School Level* (James Gallagher, Michigan State University)

22. *Metaphors for Science and Mathematics Teaching* (Kenneth Tobin)

23. *Changing the Classroom to Reflect a Constructivist Philosophy* (Grayson Wheatley, Florida State University)

24. *Incorporation of Constructivist Approaches to Learning into a Teacher Education Program* (Gaalen Erickson, University of British Columbia, Canada and Richard Gunstone, Monash University)

Improving Science Education: What Do We Know?
Edited by Barry J. Fraser and Herbert J. Walberg
(Commissioned by the International Academy of Education)

Part A: Improving Science Curriculum and Instruction

1. *Improving Curriculum* (John Keeves, Flinders University)

2. *Effective Instructional Strategies* (Avi Hofstein, Weizmann Institute, Israel and Herbert Walberg, University of Illinois)

3. *Using Student Conceptions and Constructivist Teaching Approaches* (K.C. Cheung, Institute of Education, Singapore and Reinders Duit, University of Kiel)

4. *Using Educational Technology Effectively* (Tjeerd Plomp and Joke Voogt, University of Twente, The Netherlands)

Part B: Improving Assessment and Evaluation in Science Education

5. *Student and Curriculum Evaluation* (Wayne Welch, University of Minnesota)

6. *Assessment of Learning Environments* (Barry Fraser, Curtin University, Theo Wubbels, University of Utrecht, The Netherlands and Peter Okebukola, Lagos State University, Nigeria)

Part C: Improving Teacher Education and Teacher Assessment in Science

7. *Teacher Change and Teacher Assessment* (Kenneth Tobin, Florida State University)

Part D: Contextual and Societal Issues in Science Education

8. *Improving Student Participation, Achievement and Attitudes* (John Keeves, Flinders University)

9. *Enhancing Gender Equity* (Jan Harding, UK, Lesley Parker and Léonie Rennie, Curtin University)

Part E: Conclusion

10. *Synthesis and Implications* (Barry Fraser and Herbert Walberg)

Action for Equity: The Second Decade
Edited by Léonie J. Rennie, Lesley H. Parker and Gaell M. Hildebrand
(Published by the Key Centre in 1991)

This two-volume set of contributions to the Sixth International GASAT (Gender and Science and Technology) Conference in Melbourne during 1991, brings together the work of over 130 researchers from 20 different countries. The contributions are organised into the following four focal areas of conference activity:

Reviews, reflections and syntheses of GASAT work
Current intervention projects: Design, implementation and evaluation
Current research findings: Attitudes and practices
Future directions: Challenges and possibilities.

Contributions in the area of schooling are gathered together in *Volume I: Schooling*. Contributions in the areas of Post-school Education, Employment and Living in a World Community are presented in *Volume II: Beyond Schooling*.

APPENDIX E

Publications Authored by Key Centre Staff, 1988 Onwards

Alaiyemola, F.F., Jegede, O.J., & Okebukola, P.A.O. (in press). The effect of a metacognitive strategy of instruction on the anxiety level of students in science classes. *International Journal of Science Education.*

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APPENDIX F

Papers Presented by Key Centre Staff at Annual Conferences or Meetings of Professional Associations, 1988 Onwards

Adams, C., Zadnik, M., & Treagust, D. (1991, May). *What do successful TEE physics students know about electricity and mechanics?* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Barnes, M., & Johnston, J. (1990, July). *Humanising calculus: Evaluation of a curriculum development project.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Hobart, Tas.

Barnes, M., & Johnston, J. (1990, July). *Humanising calculus: Responses to a new approach to teaching calculus.* Paper presented at the meeting of the Australian Association of Mathematics Teachers, Hobart, Tas.

Barnes, M., Johnston, J., & Wettenhall, S. (1990, December). *Humanising calculus.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Birnie, H. (1989, July). *Teaching elementary and secondary science.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Burden, R., & Fraser, B. (1991, April). *Use of classroom environment assessments in school psychology: A British perspective.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Dekkers, J., de Laeter, J., & Malone, J. (1991, May). *School science and mathematics enrolments, curriculum patterns and trends in Australia..* Paper presented at the the XVII Pacific Science Congress, Hawaii, HI.

Doran, R., Giddings, G., & Fraser, B. (1989, December). *Assessment of practical performance in science laboratories.* Paper presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Dunne, M. (1989, September). *Science education in the Pacific Island nations: Problems and prospects.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Dunne, M. (1990, May). *COMETS: collaborative curriculum in action.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Dunne, M., & Jegede, O. (1990, August-September). *Building on alternative views: Constructivism and science learning in a non-western context.* Paper presented at the meeting of the Science Teachers' Association of Nigeria, Benin-City, Bendel State.

Dunne, M., Jegede, O., & Johnston, J. (1990, July). *Shades of meaning: Constructivism and science learning in culturally diverse settings.* Paper presented at the meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Dunne, M., & Johnston, J. (1990, July). *Revealing assumptions: A critical analysis of gender issues in school science and mathematics.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

Dunne, M., & Johnston, J. (1990, August-September). *Critical questions: Issues of gender in school science and mathematics.* Paper presented at the meeting of the British Educational Research Association, Roehampton, UK.

Dunne, M., & Rennie, L.J. (1990, July). *The influence of gender, ethnicity and rurality upon perceptions of science.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

Edwards, I., & Rennie, L.J. (1991, April). *Enhancing the learning of distance education students by the use of a video-taped lesson in a topic on genetics.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Finegold, M. (1989, July). *Learning about forces: Simulating the application of students' perceptions of forces acting in simple physical systems.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Finegold, M. (1989, July). *The physics of technological systems: Encouraging poor achievers to learn physics.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Fisher, D., Docker, J., & Fraser, B.J. (1988, April). *Use of school climate assessments in improving school-level environment.* Paper presented at the meeting of the American Educational Research Association, New Orleans, LA.

Fisher. D., & Fraser, B. (1990, April). *Validity and use of the School-Level Environment Questionnaire* (SLEQ). Paper presented at the meeting of the American Educational Research Association, Boston, MASS.

Fisher, D., & Fraser, B. (1991, April). *Incorporating learning environment ideas into teacher education: An Australian perspective.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Fraser, B.J. (1988, April). *A study of exemplary science and mathematics teaching.* Paper presented at the meeting on ethnographic methods in science and mathematics education, Purdue University, West Lafayette, IN.

Fraser, B.J. (1988, April). *An overview of classroom environment research.* Paper presented at the meeting on ethnographic methods in science and mathematics education, Purdue University, West Lafayette, IN.

Fraser, B.J. (1988, October). *An overview of the activities of the Key Centre for School Science and Mathematics (Particularly for Women).* Paper presented at the meeting of the Western Australian Science Education Research Association, Perth, WA.

Fraser, B.J. (1989, January). *Instructional effectiveness: Processes on the micro level.* Invited Keynote Address presented at the meeting of the Second International Congress on School Effectiveness, Rotterdam, The Netherlands.

Fraser, B.J. (1989, March). *Learning environment research in science classes: Past progress and future prospects.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Fraser, B. (1989, April). *School effectiveness and educational productivity research.* Invited Address presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Fraser, B.J. (1989, July). *Overview of the activities of the National Key Centre.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Fraser, B.J. (1989, December). *Introduction to Key Centre for School Science and Mathematics.* Paper presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Fraser, B.J. (1989, December). *Research on exemplary science teachers.* Paper presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Fraser, B. (1990, April). *Cross-cultural analysis of assumptions underlying curriculum decisions in Australia and the United States.* Discussant for Symposium conducted at the meeting of the American Educational Research Association, Boston, MASS.

Fraser, B. (1990, April). *Developments and changes in the study of learning environments: Looking back, sideways, and forward.* Invited address presented to Special Interest Group on the Study of Learning Environments at the meeting of the American Educational Research Association, Boston, MASS.

Fraser, B. (1990, July). *Classroom climate: Its assessment and importance in science teaching.* Paper presented at the meeting of the Science Teachers' Association of South Australia, Adelaide, SA.

Fraser, B. (1990, July). *What have we learned from research on exemplary science teachers?* Invited Keynote Address presented at the meeting of the Science Teachers' Association of South Australia, Adelaide, SA.

Fraser, B. (1991, April). *Empirical, methodological and theoretical perspectives on implementation of a statewide teacher assessment system: Can a dinosaur block the view of a rainbow?* Discussant for symposium conducted at the meeting of the American Educational Research Association, Chicago, IL.

Fraser, B., Doran, R., DeTure, L., & Giddings, G. (1991, April). *Assessment and investigation of practical performance in science classrooms.* Symposium presented at the meeting of the National Association for Research in Science Teaching, Fontane, WI.

Fraser, B.J., & Giddings, G. (1989, July). *A new questionnaire for assessing science laboratory classroom environments.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Fraser, B.J., & Giddings, G. (1989, July). *Assessment and improvement of classroom environment.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Fraser, B., Giddings, G., Griffiths, A., Hofstein, A., & Merkle, D. (1990, April). *A cross-national study of science laboratory classroom environments.* Symposium presented at the meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Fraser, B., Giddings, G., & McRobbie, C. (1991, April). *Science laboratory classroom environments: A cross-national perspective.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Fraser, B. & Miller, L.D. (1990, December). *The Key Centre for School Science and Mathematics: Provisions for professional development.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Fraser, B.J., & Rennie, L.J. (1988, July). *Learning in science - Qualitative and quantitative investigation in Year 10 classrooms.* Paper presented at the meeting of the Australian Science Education Research Association, Sydney, NSW.

Fraser, B.J., & Rennie, L.J. (1988, September). *Using qualitative and quantitative methods in a study of higher level cognitive learning.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Fraser, B., & Rennie, L.J. (1990, December). *Professional development opportunities offered by the National Key Centre for School Science* *and Mathematics.* Paper presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Fraser, B.J., & Taylor, P. (1989, November). *Impact of Early Literacy Inservice Course (ELIC) on student outcomes.* Paper presented at the meeting of the Australian Association for Research in Education, Adelaide, SA.

Fraser, B.J., & Tobin, K. (1988, April). *Psychosocial environment of exemplary teachers' classrooms.* Paper presented at the meeting of the American Educational Research Association, New Orleans, LA.

Fraser, B.J., & Tobin, K. (1989, March). *Combining qualitative and quantitative methods in the study of learning environments.* Paper presented at the meeting of the American Educational Research Association, San Francisco, CA.

Fraser, B., Tobin, K., & Treagust, D. (1990, April). *Australian studies of exemplary science teaching.* Paper presented at the meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Fraser, B.J., & Treagust, D. (1989, July). *A study of exemplary science and mathematics teachers.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Fraser, B.J., & Treagust, D.F. (1990, July). *Professional development opportunities offered by the National Key Centre for School Science and Mathematics.* Paper presented at the meeting of the South Australian Science Teachers' Association, Adelaide, SA.

Fraser, B.J., Williamson, J., & Lake, J. (1988, April). *Combining quantitative and qualitative methods in the evaluation of an alternative to conventional high schools.* Paper presented at the meeting of the American Educational Research Association, New Orleans, LA.

Gallagher, J.J., & Treagust, D.F. (1991, April). *Attempts at sense making: Preservice secondary science teachers' explanations of scientific phenomena.* Paper presented at the meeting of the National Association for Research in Science Teaching, Fontane, WI.

Garnett, P., Tyson, L., & Rennie, L. (1990, May). *Tinkering with gadgets.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Giddings, G.J. (1989, April). *Three perspectives on the problems facing the science teaching profession: A cross-nation comparison.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Giddings, G. (1990, July). *Assessment and evaluation in the science laboratory.* Paper presented at the meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Giddings, G., & Fraser, B. (1989, August). *A classroom environment questionnaire for science laboratories.* Paper presented at the meeting of the Western Australian Institute for Educational Research Annual Research Forum, Perth, WA.

Giddings, G., & Fraser, B. (1989, September). *Determining student perceptions of science laboratory classes.* Paper presented at the meeting of the WA Science Education Research Association, Perth, WA.

Giddings, G., & Fraser, B.J. (1989, November-December). *Assessing the learning environment of science laboratory classes.* Paper presented at the meeting of the Australian Association for Research in Education, Adelaide, SA.

Giddings, G., & Fraser, B.J. (1989, December). *Assessing and improving science classroom environments.* Paper presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Giddings, G., & Fraser, B. (1990, April). *Cross-national development, validation, and use of an instrument for assessing the environment of science laboratory classes.* Paper presented at the meeting of the American Educational Research Association, Boston, MASS.

Giddings, G. & Fraser, B. (1990, July). *An update on assessment and evaluation in the science laboratory.* Paper presented at the meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Giddings, G., Fraser, B., & McRobbie, C. (1991, July). *Science laboratory environments at schools and universities: A cross-national perspective.* Paper presented in the meeting of the Royal Australian Chemical Institute, Perth, WA.

Giddings, G., & Rennie, L.J. (1990, July). *New initiatives of the Key Centre.* Paper presented at the meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Griffiths, A. (1991, May). *The teaching and evaluation of scientific processes.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Griffiths, A.K. (1991, July). *Secondary school students' understanding of the nature of Science.* Paper presented at the meeting of the Australasian Science Education Research Association, Gold Coast, Qld.

Hand, B., & Treagust, D.F (1991, April). *From teacher-as-technician to teacher-as-facilitator: A study of a professional development initiative involving teaching for conceptual change.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Happs, J.C., & Mansfield, H.M. (1989, March). *Students and teachers' perceptions of the cognitive and affective outcomes of some* *lessons in geometry*. Paper presented at the meeting of the American Educational Research Association, San Francisco, CA.

Harding, J. (1990, December). *Are you a gender bender?* Keynote Address presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Harding, J. (1990, December). *Mathematics in work: In reference to traditional women's work*. Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Harding, J. (1990, December). *What counts in mathematics: A view from a gender perspective*. Keynote Address presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Harding, J. *et al.* (1991, July). *Women's progression in employment in science related areas of work*. Symposium presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Harding, J., & Rennie, L.J. (1990, December). *Skills, knowledge and issues: Alternative starting points for presenting topics in Science and Technology*. Paper presented at the meeting of the Science Teachers' Association of Victoria, Melbourne, Vic.

Jackson, A., & Parker, L.H. (1991, July). *Running an education-industry forum: Women in science and technology*. Workshop presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Jegede, O.J. (1989, September). *Reading and thinking skills: An analysis of the Nigerian Integrated Science Project pupils' books*. Paper presented at the meeting of the Reading Association of Nigeria, Owerri, Imo State.

Jegede, O.J. (1989, December). *Curriculum development in science education: A socio-cultural perspective*. Paper presented at the International Symposium on World Trends in Science and Technology Education, Manila, Philippines.

Jegede, O.J. (1989, December). *Towards a philosophical basis for science education of the 1990s: An African view-point*. Paper presented at the International Conference on History of Philosophy of Science Education, Tallahassee, FL.

Jegede, O., & Fraser, B. (1989 July). *Influence of socio-cultural factors on secondary school students' attitude towards science*. Paper presented at the meeting of the Australian Science Education Research Association, Melbourne, Vic.

Jegede, O., & Fraser, B.J. (1989, August). *Attitude toward science and classroom learning environment: An analysis of students' perception of the socio-cultural niche*. Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Jegede, O.J., & Fraser, B. (1989, September). *Attitudes toward science and classroom learning environment: An analysis of students' perception of the socio-cultural niche*. Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Jegede, O.J., & Okebukola, P.A.O. (1989, March). *The effects of instruction on socio-cultural beliefs hindering the learning of science by a sample of Nigerian students*. Paper presented at the meeting of the National Science Teachers' Association, Seattle, WA.

Jegede, O.J., & Okebukola, P.A.O. (1989, April). *Proposals for sustaining students' interest in science and technology in a non-western culture*. Paper presented at the meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Jegede, O.J., & Okebukola, P.A.O. (1989, August). *Making science and technology more intelligible to rural Nigerians*. Paper presented at the meeting of the Science Teachers' Association of Nigeria, Minna, Niger.

Jegede, O.J., Taylor, J.C. & Okebukola, P.A.O. (1991, July). *Knowledge engineering: An alternative approach to curriculum design for science education at a distance*. Paper presented at the meeting of the Australasian Science Education Research Association, Gold Coast, Qld.

Johnston, J. (1989, June). *Gender inclusive teaching practices*. Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Johnston, J. (1989, August). *Gender, the hidden agenda: The influences of classrooms and classroom materials*. Paper presented at the meeting of Women in Education, Perth, WA.

Johnston, J. (1990, May). *Research and gender equity in mathematics education*. Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Johnston, J., & Dunne, M. (1990, July). *In search of different approaches to issues of gender: Exposing epistemological assumptions*. Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Hobart, Tas.

Johnston, J., & Dunne, M. (1990, July). *Process or product? Constructivism in school mathematics*. Paper presented at the meeting of the Australian Association of Mathematics Teachers, Hobart, Tas.

Johnston, J., & Kissane, B. (1989, June). *Calculators, girls, assessment: What next? - Policies for the mathematics classroom*. Paper presented at the meeting of the Mathematical

Association of Western Australia, Mandurah, WA.

Johnston, J., & Kissane, B. (1990, May). *Doing mathematics: 70 minutes of indulgence.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Johnston, J., & Kissane, B. (1990, May). *International comparisons in mathematics education.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Johnston, J., Kissane, B., & van Wyke, J. (1990, May). *Learning mathematics, investigating and groupwork: Exploring the connection?* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Johnston, J., & Malone, J. (1989, July). *Changes in curriculum structure: Implications of enrolment trends in secondary mathematics and science in Western Australia.* Paper presented at the meeting of the Mathematical Education Research Group in Australasia, Bathurst, Vic.

Johnston, J.E., & Rennie, L.J. (1990 April). *Structural change in curriculum: The implications for gender equity in science and mathematics.* Paper presented at the meeting of the American Educational Research Association, Boston, MASS.

Johnston, J., Rennie, L., & Offer, J. (1989, July). *Changes in curriculum structure: Implications for gender equity.* Paper presented at the meeting of the Australian Curriculum Studies Association, Canberra, ACT.

Johnston, J., Stubbs, P., & van Wyke, J. (1990, May). *Humanising calculus: A new approach to introductory calculus.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Karmelita, W., Miller, D., & Malone, J. (1991, July). *An examination of students' understanding of mathematics vocabulary in Years 8 through 11.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Perth, WA.

Kahle, J.B. (1990, July). *Excellence and equity in science education.* Keynote Address presented at meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Kahle, J.B., & Rennie, L.J. (1990, July). *Teachers as researchers: Gender equity in the classroom.* Minicourse presented at the meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Kandl, T. (1990, May). *Developing a feeling for fractions.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Kandl, T., Miller, L.D., Malone, J.A., Wong, K.Y., & Treagust, D.F. (1991, April). *A naturalistic study of mathematics teachers' use of diagnostic cues to enhance student understanding.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Kandl, T., Miller, L.D., Malone, J.A., Wong, K.Y., & Treagust, D. (1991, April). *Student and teacher use of diagnostics in the mathematics classroom.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Kinnear, A., Treagust, D.F., Rennie, L., & Lewis, C. (1989, September). *Introducing technology in upper primary school.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Kissane, B., & Johnston, J. (1989, June). *International comparisons in mathematics education.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Leggett, M., Treagust, D.F., & de Domenico, G. (1989, September). *Structuring a learning environment which makes it easier for students to apply physics knowledge to physiotherapy.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Lewis, P., & Treagust, D.F. (1991, April). *Strategies used by experienced science teachers to transform subject matter content knowledge into pedagogical content knowledge.* Paper presented at meeting of the National Association for Research in Science Teaching, Fontane, WI.

Lowe, R.K. (1990, July). *Diagram information and its organisation in memory: Exploring the role of skill and experience.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

McGrath, S.M., Merkle, D.G., & Treagust, D.F. (1990, April). *Students' knowledge of nutrition and fitness concepts and the relationship of that knowledge to locus of control: A comparison of parallel studies conducted in Australia and the United States.* Paper presented at the meeting of the National Science Teachers' Association, Atlanta, GA.

Malone, J.A. (1988, June). *The function strand - Some student misconceptions.* Paper presented at the meeting of the Mathematical Association of Western Australia, Muresk, WA.

Malone, J.A. (1988, July/August). *Curriculum development in mathematics - An overview.* Paper presented at the meeting of the International Congress on Mathematical Education, Budapest, Hungary.

Malone, J.A. (1988, September). *Algebra - An exploratory approach.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Malone, J.A. (1989, June). *The teacher as a researcher.* Paper presented at the meeting of

the Mathematical Association of Western Australia, Mandurah, WA.

Malone, J.A. (1989, July). *SMEC courses: A model for the development of professional knowledge?* Paper presented at the meeting of the Mathematics Education Lecturers' Association of Australia, Bathurst, Vic.

Malone, J.A. (1989, July). *The Key Centre for Teaching and Research in School Science and Mathematics: A proactive endeavour.* Keynote Address presented at the meeting of the Mathematics Education Research Group in Australasia, Bathurst, Vic.

Malone, J. (1989, December). *The National Key Centre for Teaching and Research in School Science and Mathematics: An overview of activities.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Malone, J.A. (1990, May). *Complex numbers in the year 12 syllabus.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Malone, J.A. (1990, July). *Australia's Key Centre for Teaching and Research in School Science and Mathematics. What is it doing for you?* Paper presented at the meeting of the Australian Association of Mathematics Teachers, Hobart, Tas.

Malone, J.A. (1990, July). *The quiet revolution: The role of school assessed subjects in Year 12 mathematics enrolments in Australia.* Paper presented at the meeting of the Mathematics Education Research Group in Australasia, Hobart, Tas.

Malone, J.A. (1990, September). *The role of school assessed subjects on mathematics enrolments in Western Australia.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Malone, J.A. (1990, December). *Teaching complex numbers.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Malone, J.A. (1990, December). *Test-item format: Does it make a difference?* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Malone, J.A. (1990, December). *The impact of school assessed subjects on year 12 mathematics enrolments in Australia.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Malone, J.A. (1991, May). *Paper engineering as a mathematical enrichment activity.* Paper presented at the meeting of the Mathematical Association of Western Australia, Bunbury, WA.

Malone, J.A. (1991, July). *A study of the impact of the new secondary mathematics syllabus upon teaching in Western Australia.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Perth, WA.

Malone, J.A. (1991, July). *Mathematics enrolments and subject choice in the Australian senior secondary school.* Paper presented at the meeting of the Mathematics Education Lecturers' Association, Perth WA.

Malone, J.A., & Kissane, B.V. (1990, July). *International comparisons in mathematics education.* Paper presented at the meeting of the Australian Association of Mathematics Teachers, Hobart, Tas.

Malone, J.A., & McClellan, L. (1988, June). *Graphing trigonometry functions: An innovative approach.* Paper presented at the meeting of the Mathematical Association of Western Australia, Muresk, WA.

Malone, J., & Miller, L.D. (1990, May). *Key Centre.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Malone, J.A., & Taylor, P. (1989, June). *Aboriginal participation in mathematics.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Malone, J., & Taylor, P. (1989, December). *Exemplary mathematics teachers.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Malone, J.A., & Taylor, P.C. (1991, April). *Enhancing the participation, retention and achievement of culturally different students in mathematics.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Mansfield, H.M. (1988, July). *The role of the teacher in early childhood mathematics.* Paper presented at the meeting of the International Congress on Mathematical Education, Budapest, Hungary.

Mansfield, H.M. (1988, July). *Using students' conceptual frameworks to design strategies for teaching geometry.* Paper presented at the meeting of the International Congress on Mathematical Education, Budapest, Hungary.

Mansfield, H.M. (1989, June). *Concept maps in geometry.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Mansfield, H.M. (1989, July). *The weight watcher's theorem.* Paper presented at the meeting of the Mathematics Circle of the Mathematical Association of Western Australia, Perth, WA.

Mansfield, H.M., & Happs, J.C. (1989, July). *Using concept maps to explore students' understanding in geometry.* Paper presented at the meeting of the International Group for the Psychology of Mathematics Education, Paris.

Mansfield, H.M., & Happs, J.C. (1990, July). *Learning theory, misconceptions, and teaching in geometry.* Paper presented at the meeting of

the Mathematics Education Research Group of Australasia, Hobart, Tas.

Mansfield, H.M., & Happs, J.C. (1991, July). *Difficulties in achieving long term conceptual change in geometry.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Perth, WA.

Mansfield, H.M., & Happs, J.C. (1991, July). *How we can examine students' conceptions in geometry.* Paper presented at the meeting of the Geometry Working Group of the International Group for the Psychology of Mathematics Education, Assisi, Italy.

Maor, D. (1989, September). *Development of student inquiry skills in a computerised classroom environment: A pilot study.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Moar, D. (1990, July). *Development of student inquiry skills in a computerised classroom environment: Methodological issues.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

Maor, D. (1990, August). *Development of student inquiry skills in a computerised classroom environment: Preliminary results.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Maor, D. (1991, April). *Development of student inquiry skills: A constructivist approach in a computerised classroom environment.* Paper presented at the meeting of the National Association for Research in Science Teaching, Fontane, WI.

Maor, D. (1991, August). *The effectiveness of a computerised classroom environment.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA

Merkle, D., & Fraser, B. (1990, November). *Science laboratory classroom environments in international perspective.* Paper presented at meeting of the Pennsylvania Science Teachers' Association, Reading, PA.

Miller, L.D. (1990, April). *Using mathematics-science specialists in the upper elementary grades (4-5).* Paper presented at the meeting of the National Council of Teachers of Mathematics, Salt Lake City, UT.

Miller, L.D. (1990, May). *Using mathematics-science teaching specialists in years 4 and 5.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Miller, L.D. (1990, July). *Writing to learn algebra. A report of action research in action.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Hobart, Tas.

Miller, L.D. (1990, July). *Writing to learn mathematics: Suggestions for classroom implementation.* Paper presented at the meeting of the Australian Association of Mathematics Teachers, Hobart, Tas.

Miller, L.D. (1990, August). *Preparing teachers of mathematics - Preservice and inservice programs.* Paper presented at the meeting of the National Council of Teachers of Mathematics (Western Region), Honolulu, HI.

Miller, L.D. (1990, December). *Writing to learn mathematics: Suggestions for classroom implementation.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Miller, L.D. (1991, April). *Using mathematics-science teaching specialists in the upper elementary grades.* Paper presented at the meeting of the National Council of Teachers of Mathematics, New Orleans, LA.

Miller, L.D. (1991, May). *Teacher benefits from students' writing in secondary mathematics.* Paper presented at the meeting of the Mathematical Association of Western Australia, Bunbury, WA.

Miller, L.D. (1991, July). *Writing to learn mathematics: What research says.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Perth, WA.

Miller, L.D., & England, D.A. (1991, April). *Teaching benefits from using impromptu writing prompts in mathematics classes.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Miller, L.D., Karmelita, W., & Malone, J.A. (1991, July). *Students' understanding of mathematics vocabulary in years 8, 9, 10, 11.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Perth, WA.

Miller, L.D., & Malone, J.A. (1990, December). *Professional development opportunities offered by the National Key Centre.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Okebukola, P.A.O. (1991, May). *Concept mapping for meaningful learning in science.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Okebukola, P.A.O. (1991, June). *Issues in computer education in Nigeria.* Paper presented at the Computing in Schools Conference, Fremantle, WA.

Okebukola, P.A.O., & Agholor, R.N. (1991, July). *Using JETS Program to 'catch the girls young' for science and technology in Nigeria.* Paper presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Okebukola, P.A.O., & Jegede, O.J. (1991, July). *The concept-mapping heuristic as viewed by some Australian and Indonesian science teachers.* Paper presented at the meeting of the Australasian Science Education Research Association, Gold Coast, Qld..

Okebukola, P.A.O., Jegede, O.J., & Ajewole, G. (1989, April). *Influence of research in science education on science teaching practices: Perspectives from Nigeria.* Paper presented at the meeting of the National Association of Research in Science Teaching, San Fransisco, CA.

Parker, L.H., (1991, July). *A science educator's perspective on literacy.* Paper presented at the meeting of the Australian Science Teachers' Association (CONASTA), Adelaide, SA.

Parker,. L.H. (1991, July). *Gender issues in science and mathematics education: Materials for use in the professional development of teachers.* Paper presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Punch, K.F., & Rennie, L.J. (1989, March). *Clarification of the direction of the affect-achievement relationship in science.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Rennie, L.J. (1988, April). *How can we make technology interesting for girls?* Invited Keynote Address presented at the meeting of the Third International PATT-3 (Pupils' Attitudes Towards Technology), Eindhoven, The Netherlands.

Rennie, L.J. (1988, July). *Out-of-school experiences: Do they affect achievement in science?* Paper presented at the meeting of the International Congress of Associations for Science Education World Conference, Canberra ACT.

Rennie, L.J. (1989, March). *The relationship between teacher beliefs, management and organizational processes, and student participation in individualized classrooms.* Paper presented at the meeting of the American Educational Research Association, San Francisco, CA.

Rennie, L.J. (1989, March). *The relationships between high school students' affect, participation and learning outcomes in individualized classrooms.* Paper presented at the meeting of the American Educational Research Association, San Francisco, CA.

Rennie, L.J. (1989, April). *Women in mathematics and science education.* Paper presented at the meeting of the Australian Federation of University Women, Perth, WA.

Rennie, L.J. (1989, May), *Gender equity in science and technology and computing.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Rennie, L.J. (1990, March). *Teacher education and primary science.* Paper presented at the Primary Science Conference, Point Peron, WA.

Rennie, L.J. (1990, May). *Gender and educational research.* Paper presented at the meeting of the Western Australian Institute for Education Research, Perth, WA.

Rennie, L.J. (1990, September). *Science, technology and gender: Confronting the issues.* Invited Keynote Address presented at the meeting of the Science Teachers' Association of New South Wales, Sydney, NSW.

Rennie, L.J. (1990, September). *Technology in the primary and secondary school: Why science should play a leading role?* Paper presented at the meeting of the Science Teachers' Association of New South Wales, Sydney, NSW.

Rennie, L.J. (1991, May). *Learning science — Promoting gender equity in the science curriculum.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Rennie, L. J., & Dunne, M. (1990, May). *COMETS - Australia: Collaborative curriculum in action.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Rennie, L.J., & Dunne, M. (1991, April). *Gender, ethnicity and science in Fiji: Influences on form 5 students' perceptions about science and science-related careers.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Rennie, L.J., & Fraser, B.J. (1988, July). *Structuring the learning environment and learning activities to facilitate student engagement in science classrooms.* Paper presented at the meeting of the International Congress of Associations for Science Education World Conference, Canberra, ACT.

Rennie, L.J., Fraser, B., & Tobin, K. (1989, March). *Using qualitative and quantitative methods in a study of higher-level cognitive learning in grade 10 science classrooms.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Rennie, L.J., Garnett, P., Tyson, L., & McGowan, M. (1989, September). *A new approach to teaching mechanics, or how to be a little cog in a big wheel.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Rennie, L.J., & Offer, J.A. (1988, July). *The position and future of science in the unit curriculum.* Paper presented at the meeting of the Australian Science Education Research Association, Sydney, NSW.

Rennie, L.J., & Offer, J.A. (1988, September). *The Unit Curriculum in review.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Rennie, L.J., & Parker, L. (1989, July). *Enrolment and performance of girls in the Unit Curriculum: Portents for the future.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Rennie, L.J., & Parker, L. (1989, July). *Fair and equitable assessment of boys and girls in science: Issues and practical problems.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Rennie, R.S., & Rennie, L.J. (1991, July). *Lego for girls: A cautionary tale.* Paper presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Rennie, L.J., & Treagust, D.F. (1988, May). *Science and technology here and elsewhere.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Rennie, L.J., & Treagust, D. (1989, June-July). *Measuring students' perceptions about technology: A multidimensional concept.* Paper presented at the meeting of the Australian Science Education Research Association, Melbourne, Vic.

Rennie, L.J., & Treagust, D. (1990, May). *Integrating technology education in the science curriculum.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Rennie, L.J., Treagust, D.F., & Kinnear, A. (1991, April). *Teaching technology as a design process: An evaluation of curriculum materials for middle school science.* Paper presented at the meeting of the National Association for Research in Science Teaching, Fontane, WI.

Rennie, L.J., Tyson, L., & Garnett, P. (1990, July). *Gender inclusive strategies in science.* Paper presented at the meeting of the Australian Science Teachers' Association, Alice Springs, NT.

Stocklmayer, S., & Rennie, L.J. (1991, July). *Learning science: Promoting gender inclusive science curriculum with a new video.* Workshop presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Taylor, P. (1988, September). *The impact of teacher beliefs on teaching practice.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Taylor, P. (1989, August). *Investigating the personal beliefs that influence teachers' classroom practice.* Paper presented at the meeting of the Western Australian Institute of Educational Research, Perth, WA.

Taylor, P. (1989, December). *The influence of a teacher's beliefs on constructivist teaching practices.* Paper presented at the meeting of the First International Conference of the History and Philosophy of Science in Science Education, Tallahassee, FL.

Taylor, P. (1989, December). *The influence of teacher beliefs on teaching practice.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Taylor, P.C. (1990, April). *The influence of teacher beliefs on constructivist teaching practice.* Paper presented at the meeting of the American Educational Research Association, Boston, MASS.

Taylor, P.C. (1990, August). *Teacher beliefs and constructivist teaching practices.* Invited Keynote Address presented at the meeting of the Western Australian Institute for Educational Research, Murdoch University, Perth, WA.

Taylor, P.C. (1991, April). *Collaborating to reconstruct teaching: The influence of researcher beliefs.* Paper presented at symposium entitled 'The Emerging Role of Constructivism in Changes in Teachers' Beliefs' at the meeting of the American Educational Research Association, Chicago, IL.

Taylor, P.C. (1991, May). *Teachers-as-Researchers: Towards Student-Centred Teaching.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Taylor, P.C., & Fleming, B. (1988, June). *Towards a student-centred approach to teaching mathematics.* Paper presented at the meeting of the Mathematical Association of Western Australia, Muresk, WA.

Taylor, P.C., & Fraser, B.J. (1991, April). *CLES: An instrument for assessing constructivist learning environments.* Paper presented at the meeting of the National Association for Research in Science Teaching, Fontane, WI.

Taylor, P., & Fraser, B. (1991, April). *Development of an instrument for assessing constructivist learning environments.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Taylor, P., & Malone, J. (1989, June). *Factors influencing the participation and achievement of Aborigines in secondary mathematics.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Taylor, P., & Malone, J. (1989, December). *Aboriginal participation in secondary mathematics.* Paper presented at the meeting of the Mathematical Association of Victoria, Melbourne, Vic.

Thiele, R.B., & Treagust, D.F. (1991, May). *The use of analogies in science education.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Thiele, R.B., & Treagust, D.F. (1991, July). *Using analogies to aid understanding in secondary chemistry education.* Paper presented at the meeting of the Royal Australian Chemical Institute, Perth, WA.

Tobin, K., & Fraser, B.J. (1988, April). *Factors which inhibit the attainment of high-level cognitive outcomes.* Paper presented at the meeting of the National Association for Research in Science Teaching, Lake Ozark, MO.

Tobin, K., & Fraser, B.J. (1988, April). *Impediments to the teaching and learning of high-level outcomes in high school science.* Paper presented at the meeting of the American Educational Research Association, New Orleans, LA.

Treagust, D.F. (1989, March). *The development and use of diagnostic instruments to evaluate students' misconceptions in science.* Paper presented at the meeting of the American Educational Research Association, San Francisco, CA.

Treagust, D.F. (1989, April). *Diagnostic testing to evaluate students' misconceptions.* Symposium entitled 'Toward a Unified Conception of Thinking', University of Victoria, Victoria, British Columbia.

Treagust, D.F. (1989, July). *How to publish your ideas and work in the Australian Science Teachers' Journal.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Treagust, D.F. (1989, July). *Use of diagnostic tests.* Paper presented at the meeting of the Australian Science Teachers' Association, Melbourne, Vic.

Treagust, D.F. (1990, July). *Improve your teaching: Diagnosing student conceptions and teaching for conceptual change.* Paper presented at the meeting of the South Australian Science Teachers' Association, Adelaide, SA.

Treagust, D.F. (1990, July). *Integration of technology in the school curriculum.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

Treagust, D.F. (1991, July). *Diagnosing students' understanding of chemistry concepts.* Paper presented at the meeting of the Royal Australian Chemical Institute, Perth, WA.

Treagust, D.F., Duit, R., Joslin, P., & Lindauer, I. (1990, April). *A naturalistic study of teachers' use of analogies as part of their regular teaching.* Paper presented at the meeting of the American Educational Research Association, Boston, MASS.

Treagust, D.F., Duit, R., Joslin, P., & Lindauer, I. (1990, April). *Science teachers' use of analogies: Potential and practice.* Paper presented at the meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Treagust, D.F., Duit, R., Lindauer, I., & Joslin, P. (1989, June-July). *Teachers' use of analogies in their regular teaching routines.* Paper presented at the meeting of the Australian Science Education Research Association, Melbourne, Vic.

Treagust, D.F., & Fetherstonhaugh, T. (1990, April). *Students' understanding of light and its properties following a teaching strategy to engender conceptual change.* Paper presented at the meeting of the American Educational Research Association, Boston, MASS.

Treagust, D.F., & Garnett, P. (1989, March). *Difficulties experienced by senior high school chemistry students of electrochemistry: Electric circuits and oxidation-reduction equations.* Paper presented at the meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Treagust, D.F., Glasson, P., & Leggett, M. (1988, May). *Using feedback to enhance physics teaching.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Treagust, D.F., & Graham, C. (1989, May). *Senior science - On for young and old.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Treagust, D.F., & Hand, B. (1988, July). *Application of a conceptual conflict strategy to enhance student learning of acids and bases.* Paper presented at the meeting of the Australian Science Education Research Association, Sydney, NSW.

Treagust, D.F., & Hand, B. (1991, April). From teacher-as-technician to teacher-as-facilitator: A study of a professional development initiative involving teaching for conceptual change. Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Treagust, D.F., & Haslam, F. (1988, April). *Evaluating secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier diagnostic instrument.* Paper presented at the meeting of the National Association of Science Teachers, St Louis, MO.

Treagust, D.F., & Leggett, M. (1988, September). *Tolerance of ambiguity as an effective strategy for helping learners deal with novel tasks.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Treagust, D.F., Leggett, M., & Glasson, P. (1988, July). *Instant use of evidence from collaboration research about physics teaching.*

Paper presented at the meeting of the Australian Science Education Research Association, Sydney, NSW.

Treagust, D.F., Leggett, M., Glasson, P., & Wilkinson, W. (1988, July). *Enhancing the teaching of physics through teacher-researcher interactions.* Paper presented at the meeting of the Australian Science Teachers' Association (ICASE World Conference), Canberra, ACT.

Treagust, D.F., Leggett, M., Glasson, P., & Wilkinson, W. (1989, March). *Tolerance of ambiguity as an effective strategy for helping learners deal with novel tasks.* Paper presented at the meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Treagust, D.F., Leggett, M., Wilkinson, W., & Glasson, P. (1988, April). *Enhancement of physics learning: Teacher knowledge of content and content-specific pedagogy.* Paper presented at the meeting of the National Association for Research in Science Teaching, Lake Ozark, MO.

Treagust, D.F., & Merkle, D.G. (1988, April). *Student knowledge of health and fitness concepts and its relationship to locus of control.* Paper presented at the meeting of the National Association for Research in Science Teaching, Lake Ozark, MO.

Treagust, D.F., & Paulus, G. (1990, August). *An investigation of electrical and magnetic concepts held by students who enter the physics stream of senior secondary school in Kupang.* Paper presented at the meeting of the Indonesian Association of Physicists (Jogyakarta Branch), Salatiga, Indonesia.

Treagust, D.F., Piburn, M.D., & Baker, D.R. (1988, April). *Misconceptions about gravity held by college students.* Paper presented at the meeting of the National Association for Research in Science Teaching, Lake Ozark, MO.

Treagust, D.F., & Ray, G. (1988, May). *Content and approaches for teaching Senior Science.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Treagust, D.F., & Rennie, L.J. (1991, April). *Implementation of technology within the curriculum: A case study involving six secondary schools.* Paper presented at the meeting of the National Association for Research in Science Teaching, Fontane, WI.

Treagust, D.F., Rennie, L.J., & Kinnear, A. (1991, May). *Teaching technology as a design process.* Paper presented at the meeting of the Science Teachers' Association of Western Australia, Muresk, WA.

Treagust, D.F., & Sydney-Smith, I. (1988, July). *Is the Web of Life biology course meeting the needs of biology teachers and their students?* Paper presented at the meeting of the Australian Science Teachers' Association, Canberra, ACT.

Treagust, D.F., & Sydney-Smith, I. (1990, April). *Teachers' perceptions and opinions concerning the implementation of an inquiry-oriented biology course.* Paper presented at the meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Treagust, D.F., Taylor, P., & Malone, J. (1988, September). *Aborigines into tertiary mathematics and science related courses: A curriculum project.* Paper presented at the meeting on Adult Aboriginal Education, Perth, WA.

Treagust, D.F., Tobin, K., Williamson, W.J., Gallagher, J., Yeany, R., & Fraser, B.J. (1988, April). *Interpretive research in science education.* Paper presented at the meeting of the National Association for Research in Science Teaching, Lake Ozark, MO.

Treagust, D.F., & Voges, K.C. (1988, April). *Use of a classroom environment instrument to evaluate the implementation of a non-traditional teaching approach for secondary mathematics.* Paper presented at the meeting of the American Educational Research Association, New Orleans, LA,

Treagust, D.F., Wilkinson, W., Leggett, M., & Glasson, P. (1988, April). *The teaching-learning environment in a student-centred physics classroom.* Paper presented at the meeting of the National Association of Research in Science Teaching, Lake Ozark, MO.

Waldrip, B., & Rennie, L.J. (1990, July). *Characteristics of the effective science teacher.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

Willis, S., Kenway, J., Rennie, L.J., & Blackmore, J. (1991, July). *Studies of reception of gender reform in schools.* Symposium presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Wong, K.Y. (1990, March). *Problem solving in mathematics: What can we learn from research?* Paper presented at the meeting of the Science Teachers' Association, Singapore.

Wong, K.Y. (1990, May). *Doing geometric transformations with Logo.* Paper presented at the meeting of the Mathematical Association of Western Australia, Mandurah, WA.

Wong, K.Y. (1990, June). *A strategy approach to learning mathematics.* Paper presented at the meeting of the South East Asia Conference on Mathematical Education, SEACME 5, Brunei.

Wong, K.Y. (1990, June). *Use of Lotus to teach secondary mathematics.* Paper presented at the meeting of the South East Asia

Conference on Mathematical Education, SEACME 5, Brunei.

Wong, K.Y. (1990, July). *How secondary school students learn mathematics.* Paper presented at the meeting of the Australian Association of Mathematics Teachers, Hobart, Tas.

Wong, K.Y. (1990, July). *Mathematical vitality revisited: A comparative study.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Hobart, Tas.

Wong, K.Y. (1990, August). *Helping principals to understand the mathematics curriculum: A Singapore experience.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Wong, K.Y. (1991, July). *Learning strategies in mathematics.* Paper presented at the meeting of the Mathematics Education Research Group of Australasia, Perth, WA.

Yeo, S., & Stocklmayer, S. (1991, July). *Old problem — New ideas.* Workshop presented at the meeting of the Australian Science Teachers' Association (CONASTA), Adelaide, SA.

Young, D.J. (1988, September). *The science achievement of girls in single-sex and coeducational schools.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Young, D.J. (1989, September). *Sex differences and socio-educational factors influencing science achievement.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Young, D.J. (1989, September). *Socio-educational factors influencing science achievement.* Paper presented at the meeting of the Western Australian Institute for Educational Research, Perth, WA.

Young, D.J. (1991, July). *Multilevel analysis of sex and other factors influencing science achievement.* Paper presented at meeting of Australasian Science Education Research Association, Gold Coast, Qld.

Young, D.J. (1991, July). *Multilevel analysis of sex and other factors influencing science achievement.* Paper presented at the Sixth International Gender and Science and Technology (GASAT) Conference, Melbourne, Vic.

Young, D.J., & Fraser, B.J. (1988, September). *The science achievement of girls in single-sex and coeducational schools.* Paper presented at the meeting of the Western Australian Science Education Association, Perth, WA.

Zadnik, M.G., Singer, K.P., Simpson, I.A., & Treagust, D.F. (1990, July). *An evaluation of a course designed to teach physics to students of physiotherapy.* Paper presented at the meeting of the Australian Science Education Research Association, Perth, WA.

BJF-284-30.8.91